SOCIOECONOMIC, MEDICAL, AND PSYCHOLOGICAL VARIABLES DIFFERENTIATING LEARNING DISABLED FROM SUCCESSFUL SCHOOL CHILDREN: A DISCRIMINANT FUNCTION ANALYSIS

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CHAPTER I

INTRODUCTION

The concept of learning disabilities is of relatively recent development. In the 1960's the term was coined to replace older terms formerly used to describe debilitating conditions which inhibit the learning process. Because so many diverse professions are involved in dealing with the learning disabled child, a confusion of terminology and conflicting ideas pervade current discussions found in the literature. The current study represents yet another attempt to delineate variables which can describe and predict children who will experience difficulty in the learning process. Therefore, to facilitate understanding of the study, a definition of the term will be helpful.

Considerable time and effort have been devoted to formulating an adequate definition. Perhaps the most widely-accepted formulation in current use is the following one given to Congress in 1968 by the National Advisory Committee on Handicapped Children:

> Children with special learning disabilities exhibit a disorder in one or more of the basic psychological processes involved in understanding or in using spoken or written languages. These may be manifested in disorders of thinking, listening, talking, reading, writing, spelling, or arithmetic. They include conditions which have been referred to as perceptual handicaps, brain injury, minimal brain dysfunction, dyslexia, developmental aphasia, etc. They do not include learning problems which are primarily due to visual, hearing, or motor handicaps, to mental retardation, emotional disturbance, or environmental disadvantage (USPHS, 1969). (More recent definitions have yet to be legally established.)

The road to the development of this definition and others similar to it is relatively lengthy. Historically, the concept of learning difficulty has been closely associated with that of brain damage. This association is traced to the work of Strauss and Lehtinen (1947). These researchers described a number of behaviors observed in brain damaged children, which have become known as the "Strauss Syndrome." Included are hyperactivity, impulsivity, distractibility, short attention span, emotional lability, perservation, and perceptual disturbances. The work done by Strauss and Lehtinen led to the wide-spread assumption that children experiencing difficulty in learning (who often did exhibit one or more of the behaviors listed) suffered from some degree and type of brain insult. From this work the notion of brain damage as the etiological factor behind learning difficulties became the predominant theme for a number of years. However, many complicating factors have accompanied this notion, resulting in much confusion in attempting to diagnose and remediate the children affected. Birch (1964) has noted that there is little direct evidence that children with learning disturbances can be shown to have demonstrable brain damage. Furthermore, many children with verified brain damage do not exhibit the behaviors described as characteristic. Smith (1968) has pointed out that there is a wide range in both the gradients of learning disabilities and brain injuries. The relationship between the two is not a simple correlation but rather a complex interaction of many factors.

For such reasons, many practitioners began referring to some sort of brain dysfunction rather than specific damage to the brain. The shift from the term minimal brain damage to minimal brain dysfunction enabled researchers to talk in terms of higher and lower levels of cerebral functioning rather than specific locus of brain injury. Chalfant and Sheffelin (1969) note that the term minimal brain dysfunction has value in that it avoids the issue of causation, recognizing that disorder of brain function may stem from many causes. At the same time, since the term is intended to imply that all learning and behavior are a reflection of brain function, it does suggest that difficulties may arise from within the child and not only from environmental factors.

Even so, continued confusion and dissatisfaction with etiologically-based definitions led to the introduction of the more behaviorally-oriented term "learning disability." Educators noted that for practical purposes concern might more appropriately be placed on the behavior patterns of disabled learners than upon vague neurological designations not directly relevant to remediation (Birch and Belmont, 1964). The use of the newer term represents primarily an educational movement which attempts to remove the classification of handicapped children from the medical model.

This progression from an etiological to an educational approach has spawned numerous terms. In fact, Pannbacker (1968) found 92 different terms in the literature used to describe learning disorders that are assumed to arise from brain dysfunction. Satirizing the state of affairs, Fry (1968) suggested a Do-It-Yourself Terminology Generator that could be used to construct 100 distinct terms with similar meanings to describe the disabled learner. However, in spite of the multiplicity of terms and definitions which does exist, common elements can be observed among them. Both Kirk (1968) and Clements (1969) cite the following four points as common features in all descriptions of children with learning disabilities:

1) All are retarded in school subjects and display a discrepancy between expected and actual performance.

2) All possess average or above average intellectual capacity.

3) None are assignable to major categories of exceptionality such as mental retardation or blindness.

4) All have some presumed neurologic basis for their manifest disability.

McCarthy (1971) refers to commonalities in definition as the "intact clause" and the "discrepancy clause," which correspond to the first two points listed above. Thus, while there remains considerable disagreement regarding important aspects of the definition among practitioners in the field, there are also agreed upon elements which lend some continuity to the attempts being made to study the disabled learner.

Many behavioral descriptors have been used to depict the learning disabled child. Clements (1966) lists the ten most frequently cited characteristics of learning disabled children in order of frequency as hyperactivity; perceptual-motor impairments; emotional lability; general orientation defects; disorders of attention; impulsivity; disorders of memory and thinking; specific learning disabilities in arithmetic, writing, and spelling; disorders of speech and hearing; equivocal neurological signs; and EEG irregularities. However, in spite of the apparent consensus among clinical reports (e.g., Benton, 1962; Birch, 1964; Bradley, 1957; Clements and Peters, 1962; Johnson and Myklebust, 1967; Strauss and Lehtinen, 1947) and behavior ratings of teachers and parents of children with learning disabilities (Keogh, Tchir, and Windeguth-Behn, 1974; McCarthy and Paraskevopoulos, 1969; Paraskevopoulos and McCarthy, 1972) that common characteristics are observed in these children, there is no single pattern of behavior which is manifest by all children designated as learning disabled. Thus, not all the previously-noted characteristics are found in children with learning disabilities nor are they unique to a learning disabled population. The lack of a definitely fixed pattern of behavior along with the difficulty in defining the term have contributed to difficulty in determining prevalence. Estimates range from one to forty percent of the total school population (McCarthy, 1971) with the variance in figures being determined by the definition used. In fact, Myklebust has stated (McCarthy, 1971), "Tell me how many (learning disabled children) you want to find, and I'll write you a definition that will find that many." According to McCarthy, conservative estimates using the definition given earlier include one to three percent of the total school population. Two percent is currently being suggested by the government. The children included in this estimate are those who require special remedial procedures. If milder forms of learning problems which might be ameliorated by individualizing instruction in regular classrooms are included in the prevalence figures, the percentage is increased to twenty or thirty percent.

The difficulty in defining the term and the resulting problems in determining the prevalence of learning disabilities have obvious implications for the children involved. For example, in most cases children are not detected until they reach school age. Exceptions may be seen among children who are hyperactive and thus come to the attention of professionals at an earlier age because of the associated behavioral difficulties. However, the majority of children who can be labeled learning disabled are frequently not detected until school age, and even then some are missed. The many studies which have attempted to devise adequate screening instruments or batteries give evidence of this point.

In addition, Keogh and Becker (1973) point out an important methodological paradox in reference to early identification. Having identified a child as high risk, the researcher is then obligated to intervene. Unfortunately, intervention may preclude adequate assessment of long term predictive validity of the instruments used in screening. Herein lies another reason that learning disabled children are not often identified at earlier ages.

The present study represents an attempt to address some of the difficulties which continue to exist within the field. In particular, an attempt to enumerate a number of variables that could assist in distinguishing learning disabled from successful school children at an early age was undertaken. The problem noted by Keogh and Becker did not represent an obstacle methodologically since the data analyzed were selected from an already existing pool of data.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

Even a cursory examination of the pertinent literature reveals that the research effort in the area of learning disabilities has equaled attempts made to provide a viable operational definition of the term. In fact, despite the absence of a completely satisfactory definition, a plethora of studies has been generated. These studies have focused upon diverse aspects of the problem. For example, attempts have been made to develop precise descriptions of observable behaviors, to determine the prevalence and incidence of learning disorders, and to develop effective methods of remediation. In addition, improving procedures for educational assessment and diagnosis and finding ways of delivering services to children at an early age have been explored. Considering this wide range of focus, the present literature review cannot purport to examine the area in a comprehensive vein. Rather, it is concentrated upon three more specific areas of research within the broader area defined.

First, a number of studies attempting to differentiate learning disabled from successful school children is reviewed. One purpose of including these studies is to demonstrate the diversity of variables which has previously been examined in attempting to differentiate the two groups. Secondly, studies which have attempted to provide some longitudinal perspective to the problem are discussed. Finally, studies which have utilized a multivariate data analysis are included. Occasionally, the studies do not fall exclusively within one of the three areas. In those cases, studies are discussed beneath the rubric subjectively deemed most relevant. To preclude presentation of an unnecessarily lengthy and unwieldy discourse, the studies reviewed have been limited primarily to more recent ones. A second facilitative measure was to include primarily those studies that could be listed beneath the general learning disability rubic rather than those contained within the more specifically defined areas such as reading disability. The reader will note some exceptions to these guidelines in cases where studies representing classic investigations of the problem have been included. The studies presented are ones which have examined learning problems in relation to elementary school children. Because of the different exposures to various life experiences, particularly those of an academic nature, the functioning of elementary and secondary school children with learning problems is often different on a number of test measures.

Differentiation of Learning Disabled and Successful School Children

Perusal of the literature reveals that a multiplicity of factors have been examined in attempting to discover expedient ways of distinguishing between children who manifest specific learning problems and children who are successful in school. The immediately following studies represent a sample of the kinds of variables which have been examined in attempting to distinguish characteristics of learning disabled from academically successful school children.

WISC Configurations

The WISC is considered an important component of the diagnostic battery. In addition to its use in ascertaining that the child's level of intellectual functioning falls within the normal range, more specific elements of the WISC profile are often noted. Clements and Peters (1962) distinguish three WISC patterns now regarded by clinicians as classic signs in identifying the learning disabled child. Two of these patterns involve discordance between the WISC Verbal and Performance IQ scores. These include (least frequently) a Performance score greater than the Verbal score and (more commonly) a Verbal IQ score exceeding the Performance score by 15 to 40 points. The most common pattern noted is scatter in either or both the Verbal and Performance scales of the WISC.

In regard to research, the area in which verbal-performance discrepancies have received the most thorough investigation is that of reading achievement. Numerous researchers have investigated the intellectual profile of retarded readers and have obtained highly consistent results. Belmont and Birch (1966) provide one of the more methodologically sound studies. Their study, which substantiates many earlier findings (e.g., Graham, 1952; Rabinovitch, Drew, DeJong, Ingram, and Withey, 1954; Robeck, 1962), reveals that WISC Verbal-Performance discrepancies can be used diagnostically in differentiating retarded and normal readers. This and other studies have evinced that when borderline intellectual functioning is eliminated, retarded readers are characterized by better functioning on the Performance scales and poorer functioning on the Verbal scales of the WISC.

Unfortunately, when considering learning disabled children as a group, the same clear-cut results have not been obtained. For example, a study by Ackerman, Peters, and Dykman (1971), which examined WISC Verbal-Performance discrepancies in learning disabled and control subjects, found that these discrepancies did not differentiate the two groups. Some subjects from both the learning disabled and control groups were noted to have a 15-point or greater discrepancy between verbal and performance IQ scores. However, for subjects whose scores were discordant, a finding consistent with that found in the studies of reading achievement was observed. Controls with discordant verbal-performance IQs were generally verbal dominant while discrepancy between learning disabled children's verbal-performance scores tended to reveal performance dominance. Hartlage also noted that WISC verbal-performance discrepancy did not differentiate among minimally brain injured, emotionally disturbed, and dyslexic children in his 1973 study.

Pertaining to Clements and Peters' third and most common sign, subtest scatter, the investigations which have been conducted again deal primarily with disabled readers. In 1970, Heulsman reviewed 23 studies which examined WISC subtest scores of disabled readers and concluded that a relatively well established WISC subtest pattern does exist for these children. Low scores are observed on the Information, Arithmetic, and Coding subtests, and the range of scatter is consequently greater than in children who read well. However, for learning disabled children results of a similar nature have not been as consistently observed. In fact, in one study (Ackerman et al., 1971) learning disabled children actually exhibited less scatter than did controls.

Rugel (1974) provided a somewhat different approach to the examination of WISC subtest scatter when he reviewed a number of studies which reported WISC subtest scores for disabled readers and/or learning disabled subjects. Subtests were reclassified according to Bannatyne's (1968) WISC categories: spatial--including Block Design, Object Assembly, and Picture Completion; conceptual--including Comprehension, Similarities, and Vocabulary; and sequential--comprised of Digit Span, Coding, and Picture Arrangement. Subjects were ranked according to their relative strength in these three categories. For the control subjects, no significant pattern was found. However, among the disabled students a consistent pattern was isolated. Disabled readers or other learning disabled children consistently performed more adequately on the spatial category (involving tasks of a "concrete" nature) followed by the conceptual and then the sequential category. Respectively, the latter categories correspond to functioning requiring abstraction and generalization on the one hand and to organizational capabilities on the other.

Yet another investigation of the diagnostic utility of the WISC was conducted in a series of recent studies by Rourke and his associates. Again, WISC Verbal-Performance discrepancies were under investigation but in this instance in their relation to selected verbal, auditory-perceptual, visual-perceptual, and problem-solving abilities in three groups of learning disabled children. One study (Rourke, Young, and Flewelling, 1971) examined the relationships between these variables for older children (9-14) while another (Rourke, Dietrich, and Young, 1973) studied the same relationships in younger children (5-8). For both studies, learning disabled children were divided into three groups: I, high performance--low verbal (Performance IQ exceeding Verbal IQ by 10 points); II, verbal = performance (IQ scores within 4 points); III, high verbal--low performance (Verbal IQ exceeding Performance IQ by 10 points). The three groups were compared on a number of dependent variables measuring the four functions noted above. The authors sought verification that WISC Verbal-Performance discrepancies could be used diagnostically for children as they are in determining brain-behavior relationships in adults (e.g., Reed and Reitan, 1963; Reitan, 1955). Group I was expected to perform more adequately than Group III on tasks involving primarily visual-perceptual skills. Conversely, the performance of Group III members was expected to exceed Group I members on tasks involving verbal, language, and auditory-perceptual skills. An intermediate position between Groups I and III was hypothesized for Group II. For the older children, these relationships obtained. However, in younger children, the same clear cut differences were not observed. The studies indicate that inferences about specific functioning in learning disabled children based upon WISC Verbal-Performance discrepancies must be mediated by other factors such as age.

Results of the preceding studies are reflective of the general lack of concordance in research findings to be found in much of the literature on learning disabilities. Further, they provide a good view of the contradictory findings regarding one frequently-used diagnostic indicator, WISC configurations.

Processing Dysfunctions

In accordance with the various definitions of learning disability, children who are so impaired are expected to evince various deficits in a variety of processing functions. Numerous studies have attempted to ascertain the differences which distinguish learning disabled from academically successful children in the area of visual-perceptual and visual-motor functioning. In an early review of the literature, Billingslea (1963) concluded that Bender Gestalt test findings constitute an important portion of the diagnostic assessment. Early studies (Koppitz, 1964; deHirsch, 1966; Ames, 1969) linked poor reproductions of Bender Visual Motor Gestalt Test designs with learning disorders in children. A more recent study by Ackerman et al. (1971) examined the Bender developmental error scores (Koppitz, 1964) of 82 boys with specific learning disabilities in contrast with the scores of 34 boys considered academically adequate. Analysis of the developmental errors made by subjects revealed a statistically higher incidence of immature Benders in the learning disabled group than in the normally achieving group. Even so, there were many false negatives and false positives, and the authors conclude that their findings are "not very impressive" evidence of the predictive power of the Bender.

The same study also compared the Bender findings with WISC scores. It was noted that learning disabled children with poor Benders (i.e., more errors than the mean for children of equivalent ages in Koppitz's normative sample) also had lower WISC scores than those with adequate Benders. In general, controls had significantly higher Verbal and Full Scale WISC IQs than did the learning disabled children and tended to excel on the following subtests: Information, Arithmetic, Similarities, and Digit Span. Normal achievers with poor Benders were no different on IQ variables than those with adequate Benders. The authors suggest that "it is the combination of a number of adverse signs which distinguishes learning disabled from normally achieving children" rather than any one particular indicator.

Other studies have focused upon additional variables considered relevant to the processing deficits assumed to exist among learning disabled children. In addition to studies which have investigated perceptual-motor functioning such as the ones discussed above, other processes have received attention. For example, a study by Koppitz (1973) examined the performance of learning disabled children on the Visual Aural Digit Span Test (VADS), a test of short-term memory and intra- and intersensory integration. The test consists of four subtests utilizing different combinations of presentation and recall (e.g., aural presentation-oral recall; visual presentation-written recall, etc.). In this study, control subjects scored higher on the visual-oral, visual-written, and aural-written subtests. In fact, only the aural-oral subtest failed to yield significant differences between the control and learning disabled subjects. According to Koppitz, the study supports the contention that children with learning problems "perform markedly below average on tasks that require integration, sequencing, and recall of visually presented symbols." Likewise, these children experience more difficulty "remembering and integrating auditorily presented material and translating it into written symbols." In sum, the performance of learning disabled children showed marked immaturity or malfunction in intersensory integration and memory when compared with the performance of average school children.

Senf and Freundl (1972) investigated the running memory functioning of children with learning disabilities compared with that of appropriate age and IQ controls. Subjects were administered four, five, and six-digit trials to both auditory and visual modalities. Two types of errors were assessed: 1) a gross error was scored for omissions, and 2) an order error for stimulus items recalled in an incorrect position. Both gross errors and order errors were more numerous among the learning disability group and also increased disproportionately for this group with increasing trial length. Modality of the stimulus provided a significant source of variation with visual trials being more difficult than auditory ones. The authors conclude that learning disabled children are inferior in performing tasks involving sequential memory. Further they hypothesize that an explanation in terms of attentional processes rather than immediate memory may be more adequate in explicating the differences observed in their study, especially since learning disabled children performed less adequately than controls on both visual and auditory tasks.

Anderson and his associates have conducted a number of studies investigating vigilance, one aspect of attention. In one study (Anderson, Halcomb, and Doyle, 1973), it was hypothesized that learning disabled children could be differentiated from nondisabled children on two dependent variables, correct detections and false alarms. Subjects were instructed to respond to pairs of flashing lights presented in specified combinations. Instructions were given to respond only to the third combination, which was presented among the other combinations at two second intervals. Learning disabled children did differ from control children in consistently producing fewer correct detections and more false alarms. They also had more difficulty in attending to the monotonous task stimuli than did the control subjects. Both findings support the importance of vigilance in the preclusion of more optimal functioning for learning disabled children.

Still another study focusing upon the presumed processing deficits in learning disabled children was conducted by Rudel and Denekla (1974) who examined the WISC Digit Span performance of 297 children with learning disabilities. For these children, the mean Digit Span scaled score fell well below overall measures of intelligence. Digits backward contributed more heavily to the poor overall performance than digits forward for most subjects. The significance of the study in terms of processing deficits in learning disability children is indirect and depends upon acceptance of the authors' contention that repetition of digits forward requires a serial-ordering process closely related to language ability while digits backward involves turning a temporal sequence into one with spatial coordinates. Thus, differential performance in forward and backward digit recall may be useful in pinpointing quite specific learning problems. In terms of differentiating learning disabled from successful school children, the relationship of Digit Span and general measures of intelligence as noted above may be important.

One further study that will be considered in this section, although not as directly related to simple processing functions as most of the studies presented above, was done by Wiig, Semel, and Crouse (1973). These investigators compared the application of morphological rules by children with specific learning disabilities to that of academically achieving controls. Thus, much more complex processes such as abstraction and generalization were under study. The study did reveal that learning disabled children gave significantly fewer correct responses on an experimental test of morphology than did controls. In addition, learning disabled children evinced less predictable patterns of difficulty than did control subjects, and they also evidenced lack of transfer of phonological conditioning rules across morphological categories. Learning disabled children generally showed a three to four year delay in the acquisition of morphology. This study bears upon more complex types of processing than those studies discussed above but does again reveal that learning disabled children have been distinguished from successful school children on yet another variable.

Inclusion of a variety of studies in this section is intended to present some notion of the kinds of processing variables which have been investigated among learning disabled children. From this discussion, it is obvious that a consistent thread does run through the findings of many of the studies which can be included beneath this rubric. Learning disabled children have frequently been shown to function less adequately in areas which require the ability to process various kinds of information. Although some studies have revealed less conclusive results than others or perhaps have been able to indicate no differences between learning disabled and successful school children, many studies have repeatedly discovered the kinds of differences discussed above.

Neurological Functioning

Neurological dysfunction of a subtle nature has been considered a significant feature of many learning disabled children. However, detection of neurological deficits is often difficult if not impossible. The value of the classical neurological approach in the diagnosis of learning disabilities is extensively questioned. Small (1973) notes that there is increased evidence that the neurological procedure is more productive when extended beyond subcortical assessment of reflexes to include equivocal signs, finer signs, and age-specific assessment of sensory, motor, integrational, and cognitive functions. The value of the EEG has been similarly questioned. Both diagnostic measures have received some empirical investigation.

Hartlage and Green (1973) note that evidence supporting a relationship between the EEG and intellectual abilities in children is inconclusive. While some studies support such a relationship (e.g., Liberson, 1966; Vogel and Broverman, 1964), others do not (e.g., Ellingson, 1966; Grossman, 1966). Freeman (1971) reviewed 56 studies related to neurological functioning in children and concluded that for both the EEG and the neurologist's assessment medical diagnosis has only limited application to educational assessment. He notes that there are currently too many discrepant results to make conclusive statements and specifically terms the use of the EEG in diagnosing learning disabilities as the "marriage of convenience."

Keeping these points in mind, Hartlage and Green investigated the intellectual and academic performance of 111 children classified on the basis of locus of EEG abnormality. Intellectual measures included 15 WISC variables while academic measures were obtained from the Wide Range Achievement Test. EEG abnormality was classified as normal, diffuse, or right or left hemisphere. Analysis of variance revealed only one significant difference. This difference which occurred on the WISC Coding subtest was deemed artifactual. The authors conclude that there may be "little payoff in terms of predicting specific areas of intellectual or academic impairment in learning disabled children" on the basis of EEG classification.

An interesting innovation in the use of the EEG (Tymchuk, 1970) suggests that continuous EEG recordings made while a child is performing a task may show that disruption of learning is correlated with transient EEG abnormalities. Piggott (1972) monitored EEG readings of an 11-year-old girl with nonspecific EEG abnormality and mild cyscalculia under five different conditions: 1) rest; 2) key pressing; 3) learning task; 4) arithmetic; 5) easy reading. Significantly greater EEG discharge activity was observed when the subject was working on the arithmetic or learning tasks. The question is raised if this subject might not represent a group of children who show EEG disorganization under stress with consequent effects upon school functioning and behavior.

The immediately preceding studies demonstrate the lack of concordance in regard to studies of neurological functioning among learning disabled children. Likewise, the earlier studies cited reveal broad areas of discordance among research findings related to other aspects of functioning among learning disabled and successful school children. While some investigators have found support for basic differences in the functioning of these two groups of children, others have not. Studies investigating WISC Verbal-Performance discrepancies and EEG relationships have revealed a number of contradictory results. On the other hand, many of the studies of other kinds of functioning have yielded positive results related to basic differences in the manner in which learning disabled and successful school children function. These points reveal the value of further studies such as the current investigation designed as an attempt to discover variables capable of effectively differentiating the two groups.

Longitudinal Studies

Few studies of learning disabled children are truly longitudinal in a "long-term" sense. The majority of the studies which do extend over any time period at all are concerned with efforts to screen for children who are educationally at risk. These studies are primarily predictive in nature and therefore represent attempts to maximize predictive validity. Most extend over several school years at the most. Both individual screening instruments and combinations of different tests and procedures have been utilized and have subsequently been examined experimentally to ascertain their efficacy in screening for learning problems. Since the attempts to develop effective screening devices comprise a significant portion of the research effort which has been devoted to investigation of the learning disabled child, representative studies will be included in this section. It should be remembered that these studies are not longitudinal in the strictest sense. Furthermore, many of these studies have investigated reading achievement rather than general learning problems. However, because of the impact of these studies upon the field and their close relationship to the more general studies, several will be cited briefly below.

One early study, which is considered a classic investigation within the field, was conducted by deHirsch, Jansky, and Langford (1966). This study attempted to test the hypothesis that reading achievement could be predicted by the evaluation of young children's motor, perceptual, and linguistic behavior. The authors developed a Predictive Index comprised of ten tests, which they recommended be administered to all kindergarten children during the second half of the school year. They contend that the decision regarding first grade entrance should then be based primarily upon the child's score on this index. A 1973 follow-up of the original study shows that 76% to 83% of the children tested in kindergarten with the original index had earlier been correctly identified as reading failures.

A number of recent studies have utilized modifications of the Predictive Index or have adopted a similar rationale for developing multifactor screening instruments. One such study (Eaves, Kendall, and Crichton, 1974) utilizes a multiple regression data analysis and will be discussed in the following section. Another study by Adelman, Feshback, and Fuller (1973) also used a deHirsch-type rationale in attempting to identify predictive factors. In fact, the Kindergarten Student Rating Scale (KSRS) developed by the authors and consisting of 41 items dealing with cognitive, affective, and social functioning in kindergarten classrooms was compared to the Predictive Index. Of the two, the KSRS consistently emerged as the better predictor. WPPSI IQ score ranked third but only increased the multiple correlation from .63 to .64. The KSRS alone yielded a correlation coefficient of .57. Both the KSRS and the deHirsch were found to be 75% accurate in predictions of first grade reading performance. Since both instruments rely heavily upon teachers' ratings, the study indicates that kindergarten teachers' ratings can predict first grade reading performance as well as a psychometric battery designed for that specific purpose.

The proliferation of these kinds of studies indicates that the trend in developing screening techniques is primarily toward the utilization of multifactor screening instruments and procedures rather than reliance upon a single test or procedure. In fact, Serwer, Shapiro, and Shapiro (1972) combined a number of commonly-used intelligence and readiness tests purported to predict first grade achievement. In all, eleven different tests were administered and evaluated against four subtests of the Metropolitan Readiness Tests, which served as criterion measures. The most striking finding of this study was that teachers' ratings represented better predictors than did standardized test measures.

The findings of these two studies bring to light one area of exception to the trend toward the use of multifactor screening devices. Many studies have either incorporated teacher assessments or examined this variable solely. Furthermore, numerous studies (e.g., Bryan and McGrady, 1972; Farr and Roelbe, 1971; Ilg, Ames, and Apell, 1965) report the accuracy with which teachers are able to identify high-risk behaviors among their students. Most of these studies involve assessment over some time period. For example, Keogh and Smith (1970) reported that 90% of the children rated by kindergarten teachers on a reading readiness scale were achieving in the predicted directions in fifth grade, and Ferinden, Jacobsen, and Linden (1970) discovered that teachers were 80% accurate in their prediction of learning problems in a sample of kindergarten children. Keogh, Tchir, and Windeguth-Behn (1974) looked specifically at the sensitivity with which teachers respond to mentally retarded, learning disabled, and emotionally disturbed children. This study revealed that teachers do tend to agree about a number of characteristics that are attributed to high risk students.

A final study of interest among the many predictive studies is one reported by Severson (1972). This study also included a variety of assessment instruments evaluated against a first grade end-of-year achievement test. A unique aspect of this study is the departure from traditional diagnostic approaches. As many of the standardly-used tests were discovered to have relatively low predictive validity, Severson shifted focus to a process he terms diagnostic teaching. This process utilizes a systematic examination in the change in learning rate as a child is exposed to a variety of teaching formats. Thus, a more individualized approach to prediction and, by extension, to remediation is provided. Severson posits that this approach may have significant utility in working with learning disabled children in both respects.

The studies just discussed are representative of the many investigations focusing upon prediction and early identification of learning problems. While they have some relevance to a longitudinal approach, several studies of more direct relevance have also been conducted. One study by Silver (1971) and a second by Hoffman (1971) are more directly related to the present study because they are longitudinal in a more strict sense. Furthermore, these studies examine variables of the same type included in the current study.

Silver examined an extensive collection of pre, peri, and postnatal information for 556 children who attended a special school of learning disabled children. The study was designed to explore the possibility of a familial pattern for children having the neurological learning disability syndrome. For each child, there were diagnostic data confirming the diagnosis of this syndrome. In addition to the diagnostic data, Silver collected and analyzed questionnaire data covering the following categories: the child's sex, age, birth order, and if adopted; history of pregnancy and delivery (e.g., prematurity, Rh factor); medical history of the child (illnesses, hospitalizations); history of mother, father, or siblings having similar learning disabilities as a child; developmental history of child (motor, language, psychological, and social development); history of impulsivity; and history of medication. Data were analyzed in two groups; those children having a positive family history of learning disability were compared to those children not revealing a positive family history for learning disability. Silver concluded that in each family with a positive history of learning disabilities information generally considered suggestive of central nervous system stress appeared less significant in light of the family data. For example, where a previous miscarriage could be cited, an older sibling born prior to the miscarriage also had similar learning disabilities. Learning disabled children born prematurely had siblings not born prematurely but also exhibiting learning disabilities, and so on. Silver notes that these kinds of findings were observed in 30-40% of the cases in the study, suggesting that a dysfunctioning nervous system may have been inherited. He concludes that even though prenatal, perinatal, or postnatal difficulties were observed, the data indicate that the difficulties may not have been a factor in producing the syndrome as siblings without the same or other difficulties also exhibited learning disabilities.

Hoffman conducted a longitudinal study of a similar nature although he was interested solely in differentiating learning disabled from successful school children. He did not attempt to establish a familial pattern but instead reviewed the case histories of 1,000 children to determine if medical history could identify as early as the age of two the child with low potential for learning.

The data reviewed included lengthy family histories in addition to the child's history, which was comprised of perinatal, developmental, medical, psychological, and educational information. Aberrations from normal expectancies for a number of variables observed in the learning disabled children were tabulated. From those occurring most frequently, test items for comparison with frequency of occurrence in children not exhibiting learning problems were selected. The most frequently-occurring anomalies were those concerned with perinatal and developmental histories. Examples of the former include prematurity, postmaturity, and induced labor while abnormal creeping, late walking, or prolonged tiptoe walking represent examples of the developmental anomalies. Using these kinds of criteria, the case histories of 100 children with learning problems were compared with the case histories of 200 children who demonstrated satisfactory performance in school. The frequency of occurrence of abnormal perinatal history was tabulated for the two groups. For perinatal history, six categories (difficult delivery, cyanosis, adoption, prolonged labor, blood incompatibility, and prematurity) had a significantly higher rate of occurrence among learning disabled than among successful students. For the developmental criteria, abnormal histories in five areas were prevalent among the learning disabled group. These included late or abnormal speech, late or abnormal creeping, late walking, prolonged tiptoe walking, and ambidexterity after the age of seven. Ninety-three percent of the learning disabled children evinced one or more abnormalities in the eleven areas. Only seven percent of the learning disabled children as compared to 78% of the passing students had a normal history in the 11 areas. Hoffman concludes that no single aberration in the perinatal and early developmental periods for his subjects could be considered an indicator of potential learning problems. Rather, problems were related to a constellation of anomalies such as the ones noted above.

The two preceding studies represent the most complete attempts to investigate learning disabilities from a longitudinal perspective discovered within the recent literature. As noted, other studies have been concerned with developing adequate screening devices and cover much shorter time periods. Furthermore, many studies have been concerned with prediction of specific problems such as reading disability and have not examined more general learning problems of the type implied by current definitions. Even in the studies which do view the problem from a longitudinal perspective, dissimilar approaches make the findings and their explanations contradictory. The need for further investigation of this nature is clearly indicated.

Multivariate Studies

The use of a multivariate statistical analysis in studying learning disabled children has been recommended by several researchers (e.g., Serwer et al., 1972) whose studies have already been discussed. In addition, other individuals have suggested that such an analysis would provide not only an appropriate but a highly efficacious means of investigating the problem. Even though the suggestion has been made by various individuals, the studies which have utilized this statistical design comprise only a small portion of the research devoted to the study of learning disabled children. Several studies which have made use of this type of statistical design do exist and are discussed in this section.

One of the earlier studies utilizing a discriminant function analysis was conducted by Ackerman et al. (1971). While the study was quite extensive in its comparison of learning disabled and normal controls, the collective effect of the WISC variables as determined by discriminant analysis is particularly germane to the current study. Discriminant analysis of ten WISC subtests (Information, Comprehension, Arithmetic, Similarities, Digit Span, Picture Completion, Picture Arrangement, Block

Design, Object Assembly, and Coding) was carried out. Five of the ten subtests were found to classify the two groups with 76% accuracy. These subtests include Information, Comprehension, Arithmetic, Digit Span, and Block Design. Scrutiny of individual subtests revealed that controls scored higher than learning disabled children on all verbal subtests as well as on all performance subtests except Block Design, on which the two groups performed equally well, and Mazes, on which the performance of learning disabled children exceeded that of the controls.

A more recent study (Eaves, Kendall, and Crichton, 1974) used multiple predictors to screen for children who might show signs of minimal brain dysfunction and who might be expected to have difficulty in school. This study examined 196 variables including a Modified Predictive Index (MPI) based on the deHirsch test, a Teacher's Checklist (TCL), and for a subgroup of 50 children an extensive psychological and neurological examination. Of particular relevance to the current study are the results of a step-wise multiple regression analysis used to select a subset of variables forming the best possible combination for prediction and a discriminant analysis used to select a subset of variables for their ability to discriminate optimally between the groups.

For the reading portion of the Cooperative Primary Tests (CPT), the criterion measures used, eight predictors provided efficient prediction. For the listening section of the CPT, three variables predicted efficiently, and for the word analysis subtest, there were four variables which contributed to an efficient prediction system. No specific patterns were noted in these variables, but the study is important since it represents an initial attempt to utilize discriminant function analysis in examining learning disabled children.

A final study utilizing multivariate data analysis is reported by Satz and Friel (1974). This study is an ongoing project designed to identify the precursors of developmental dyslexia. Multivariate analysis of 22 variables included in a test battery administered to 497 kindergarten children correctly classified 84.4% of both high and low risk children. The low risk group consistently performed more adequately than did the high risk group although five variables did not differentiate the two groups. A step-wise regression analysis revealed that four variables produced a rate of correct classification of 81.6%. Inclusion of the remaining 18 variables only increased the hit rate to the previously-noted 84.4%. The Finger Localization Test, Recognition-Discrimination Test, Day of Testing, and Alphabet Recitation represent the variables providing the highest percent of correct classification.

Obviously, multivariate data analysis of learning disabled populations has a relatively recent appearance among discussions in the literature. The studies discussed above clearly reveal the need for continued investigation of this nature. Not only are there few studies of this type but the ones which do exist also frequently lack replication and cross-validation. Definitive test patterns and predictor variables have yet to be isolated. The current investigation represents an attempt to provide further analysis utilizing this statistical design.

CHAPTER III

STATEMENT OF THE PROBLEM

The literature review, which covers only a restricted range of the studies that have been designed to investigate a variety of problems, reveals clearly that a diversity of both research topics and findings exists within the field. Several practitioners have commented upon the lack of concordance regarding the various aspects of definition, diagnosis, remediation, and etiology that persists. Ackerman et al. (1971) have noted that "despite a seeming plethora of information, there is little agreement concerning diagnosis, remediation, or etiology." As late as 1974, Bryan noted that there are "many gaps in our knowledge as many studies that should be done haven't been done." Furthermore, she contends that there have been few attempts to replicate important studies. In her words, "there are simply not enough data."

Bryan notes that the empirical research which has compared learning disabled to academically successful school children has provided little support for the currently existing stereotype of the learning disabled child. She purports that researchers have been unable to demonstrate that learning disabled children have "simple perceptual problems, hyperactivity, difficulty with simple cross-modal integration, minimal brain damage, or (frequently even) normal intelligence." As noted in an earlier chapter, these are some of the characteristics frequently cited in describing learning disabled children, and ones which have gained considerable clinical validation among professionals within the field.

The studies presented in the literature review give some indication of this state of affairs. As noted, even defining the term continues to be a point of controversy. As late as 1971, McCarthy stated that the problem of definition remained the most crucial issue in the field. The viewpoints exemplified in Bryan's and McCarthy's statements clearly indicate the need for continued research. Several individuals have suggested that the problem would lend itself readily to multivariate analysis. However, there are few studies of this nature at this point in time. In addition to a multivariate statistical design, the importance of longitudinal studies for providing an effective means of predicting later school problems has been noted. Currently there are only a small number of studies that can be construed as longitudinal. The combination of multivariate analysis with data collected over a period of years is even more rare. Also, in the instances where these kinds of studies do exist, there have typically been few attempts to cross validate or to replicate findings--hence the "gaps" referred to by Bryan.

The current study was an attempt to fill in these kinds of "gaps" which exist in the literature. An attempt was made to elucidate variables that could distinguish between learning disabled and successful school children at as early an age as possible. The practicable significance of the study can be seen in the importance of being able to differentiate a learning disabled population from a group of successful students so that effective remediation can be planned and implemented early.

Investigation of the problem was conducted in the following manner. Longitudinal data collected in an earlier study (from July, 1959, through January, 1974) were analyzed by means of four separate linear discriminant function analyses. The analyses were conducted on data collected at birth, at eight months, at four years, and at seven years. The data included socioeconomic information as well as information from obstetrical and birth records and from intermittently administered medical and psychological evaluations. The study attempted to discover a small number of variables out of over 200 that were analyzed that might provide differentiation between two groups, one composed of learning disabled children and the other consisting of children who had experienced no academic difficulties. The statistical analysis also provided a subset of variables at each age that yielded the best prediction system for classifying the children into groups. Cross validation utilizing the predictors from this system revealed the accuracy with which children could be classified into groups. As these comments indicate, the study was an attempt to combine longitudinal data with multivariate data analysis, a combination which has been suggested as potentially useful but which has been largely absent from most studies of learning disabled children in comparison to academically achieving children.

CHAPTER IV

METHODOLOGY

Subjects

This study employed 92 children selected from an earlier longitudinal program funded by the Department of Health, Education, and Welfare, Public Health Service. This program, entitled the Collaborative Study on Cerebral Palsy, Mental Retardation, and Other Neurological and Sensory Disorders of Infancy and Childhood (COLR), was conducted at 14 major institutions including the University of Tennessee Medical Units, Memphis, Tennessee. The program extended over a period of 15 years and has continued to be a data source for a variety of individual studies such as the present one. A quarterly publication provides abstracts of the current analyses being conducted utilizing these data. In addition, data from the earlier portion of the study were compiled, and the relationships between a variety of prenatal and neonatal conditions and major central nervous system disorders were explored.

For the current study, the subjects utilized were taken from those subjects of the COLR study sampled through the University of Tennessee Medical School. Data collection for the COLR study was begun for each subject during the time period between July, 1959, and January, 1966. The final data were collected following the eighth birthdays of the last subjects selected for the study. Hence, 1974 was the final year for data collection. For the Tennessee portion of the COLR study, an attempt was made to collect data from every fifth pregnancy in the City of Memphis Hospitals. As noted, each child was followed for eight years, and an extensive pool of information was collected. Detailed family and individual histories were obtained; careful prenatal evaluations were procured at intervals throughout pregnancy; and labor and delivery were precisely observed. The infant was studied during the neonatal period and examined periodically for the ensuing eight years. Psychological, neurological, and pediatric examinations were among the data collected at intervals following the neonatal period. The data analyzed in the present study were drawn from this information.

The 92 subjects used in this study were selected in the following manner. Forty-six children who had been referred for psychological evaluation, diagnosed as learning disabled, and placed in a learning disability classroom in the City of Memphis School System and who had also been included in the COLR study were located. At the time that data for the current study were compiled, these children were enrolled in the public school system in Memphis. The learning disability diagnosis was determined through a standard evaluation procedure used within the school system. The children were not re-evaluated for this study, and specific test results were not obtained from the school system. Only the learning disability diagnosis was available. This diagnosis was made within the school system on the basis of the following standard test battery: WISC or WISC-R, Bender Visual Motor Gestalt Test, Goodenough Draw-A-Person Test, Wide Range Achievement Test, and Gray Oral Reading Test. All children referred were given the preceding tests with additional testing conducted for children whose difficulties required more specific delineation.

After the 46 children identified as learning disabled were located, they were matched with 46 children also currently enrolled in the City of Memphis School System. The second group of children had not experienced any difficulty in school and were attending regular classes. The control group members were selected by a matching process that equated the groups for age and sex. The matching process was conducted in the following manner. For each child of the learning disability group, birth date was noted and a child of the same sex also born on that date or the most immediate date following was selected. By checking records of the public school system, it was then determined that the second child was currently enrolled and that he or she had never been referred for evaluation or placed in any type of special education class. If a child had experienced difficulties in school, another subject from the COLR study who could meet the criteria was selected. This process was continued until 46 nondisabled learners were matched with the disabled learners for age and sex. Because of the manner in which subjects were selected for the COLR study, all of the 92 children finally selected for inclusion in the present study were black youngsters from lower socioeconomic status families. (Average income of the children's families was $2,837 at the time of birth. By the time the children were seven, the family's average income had only grown to $5,034. The parents' educational level was ninth grade for mothers and eighth grade for fathers.)

Predictor Variables

The variables under investigation were selected from the data collected during the COLR study described in the preceding section.

These variables include information taken from obstetrical and birth records, from neurological and other medical examinations, and from psychological evaluations. In addition, some socioeconomic data are included even though the matching procedure employed made it unlikely that any significant differences would be discovered among the group means of these data. Inclusion of the socioeconomic data served partially as a check upon the type of subjects included in the study, i.e., lower socioeconomic black children. Such a factor has obvious implication for interpreting and generalizing the study's results since most past studies of learning disabled children have not focused upon a single ethnic or socioeconomic group.

The specific variables included in the study are listed below along with the manner in which they were entered into the computer for analysis. Elaboration of the variables and of the scoring system is provided when necessary. Four separate analyses were conducted, and the variables are listed as they appeared in the respective analyses. Analysis was conducted on data collected at or before birth, at eight months, at four years, and at seven years.

Birth Data

The first analysis conducted included a number of socioeconomic variables in addition to data collected at birth or immediately following birth. The variables selected for analysis at this stage of the study are listed below. Eighty variables are shown. However, for this level of the study (as for the seven year level) additional variables were initially available. Since the computer's capacity was only 80 columns, the variables found insignificant were dropped in order to accommodate the additional variables. The Appendix provides a listing of the statistically insignificant variables dropped after the initial computer run.

Variable[1]	Computer Code
1...sex	0--male 1--female
2-7...marital status of parents at child's birth	
2...married	0--no 1--yes
3...divorced	0--no 1--yes
4...separated	0--no 1--yes
5...single	0--no 1--yes
6...common law married	0--no 1--yes
7...widowed	0--no 1--yes
8...birth order	1....n
9...number in family	2....n
10-11...type of family	
10...nuclear family	0--no 1--yes
11...extended family	0--no 1--yes
12...level of mother's education	years
13...level of father's education	years
14-15...primary caretaker	
14...mother	0--no 1--yes
15...other relative	0--no 1--yes
16...mother worked during pregnancy	0--no 1--yes
17...type of labor	0--spontaneous 1--induced
18...rupture of membranes	0--spontaneous 1--induced
19-20...type of delivery	
19...vaginal vertex	0--no 1--yes
20...Cesearean section	0--no 1--yes
21...duration of labor	minutes

[1]For variables 40-73, measurements or evaluations were made at three different times for each child: 24 hours after birth, 48 hours after birth, and 72 hours after birth. The presence of anomaly at any one of these times was considered sufficient occurrence for inclusion in the analysis.

Variable	Computer Code
22-24...delivery of head	
22...controlled manually	0--no 1--yes
23...controlled with forceps	0--no 1--yes
24...uncontrolled	0--no 1--yes
25-26...delivery of placenta	
25...manually extracted and separated	0--no 1--yes
26...manually extracted only	0--no 1--yes
27...condition of placenta	0--not intact 1--intact
28-31...cord pathology	
28...none	0--no 1--yes
29...around neck	0--no 1--yes
30...around body	0--no 1--yes
31...around extremities	0--no 1--yes
32...abnormal fetal heart rate (under 110; above 160)	0--absent 1--present
33...meconium and/or staining	0--absent 1--present
34...placental abnormalities	0--absent 1--present
35...uterine stimulant used	0--absent 1--present
36...gestation	weeks
37...birth weight	to nearest .1kg
38...head circumference	to nearest cm
39...chest circumference	to nearest cm
40...cyanosis	0--absent 1--present
41...jaundice	0--absent 1--present
42...facies (from normal in appearance to abnormal but not of diagnostic significance as in Mongolism; e.g., asymmetry)	0--normal 1--abnormal
43...head normal	0--absent 1--present
44-46...respirations	
44...normal	0--absent 1--present
45...labored	0--absent 1--present
46...shallow	0--absent 1--present
47...appearance of skin	0--normal 1--abnormal

Variable	Computer Code
48-50...heart	
48...normal	0--absent 1--present
49...murmur	0--absent 1--present
50...irregular rhythm	0--absent 1--present
51-52...moro response	
51...obtained with ease	0--no 1--yes
52...obtained with difficulty	0--no 1--yes
53-54...cry	
53...normal	0--no 1--yes
54...abnormal	0--no 1--yes
55-59...motor activity	
55...normal	0--no 1--yes
56...tremulous	0--no 1--yes
57...rapid, jerky	0--no 1--yes
58...myoclonic	0--no 1--yes
59...writhing	0--no 1--yes
60-62...tone of upper extremity	
60...hypotonic	0--no 1--yes
61...normal	0--no 1--yes
62...hypertonic	0--no 1--yes
63-64...tone of lower extremity	
63...hypotonic	0--no 1--yes
64...hypertonic	0--no 1--yes
65-67...tone of neck flexor	
65...hypotonic	0--no 1--yes
66...normal	0--no 1--yes
67...hypertonic	0--no 1--yes
67-70...tone of neck extensor	
68...hypotonic	0--no 1--yes
69...normal	0--no 1--yes
70...hypertonic	0--no 1--yes
71-73...tone of trunk	
71...hypotonic	0--no 1--yes
72...normal	0--no 1--yes
73...hypertonic	0--no 1--yes
74...diagnosis by weight	0--term 1--premature
75-77...dysmaturity	
75...absent	0--absent 1--present
76...equivocal	0--absent 1--present
77...present	0--absent 1--present

Variable	Computer Code
78-80...clinical impression	
78...normal	0--no 1--yes
79...CNS defect or injury	0--no 1--yes
80...congenital malformation other than CNS	0--no 1--yes

Eight Month Data

The second analysis, comprised of data collected at eight months, included the following 64 variables.

Variable	Computer Code
1...basal age (Bayley Scales of Mental & Motor Development)	months
2...ceiling age (Bayley scales of Mental & Motor Development)	months
3-31...Bayley Mental Scale Items[2]	
3...item 68 pulls string, securing ring	0--fail 1--pass
4...item 69 enjoys sound production	0--fail 1--pass
5...item 70 lifts cup by handle	0--fail 1--pass
6...item 71 retains two cubes	0--fail 1--pass
7...item 72 attends to scribbling	0--fail 1--pass
8...item 73 looks for dropped object	0--fail 1--pass
9...item 74 manipulates bell with interest in details	0--fail 1--pass
10...item 75 responds playfully to mirror	0--fail 1--pass
11...item 76 vocalizes four different syllables	0--fail 1--pass

[2]Items 68-96 of the mental scales were included on the basis of a frequency distribution which revealed that only these items did contain differences for the subjects sampled. Lower and higher item numbers were consistently passed or failed by all subjects of the sample.

Variable	Computer Code
12...item 77 pulls string purposefully to secure ring	0--fail 1--pass
13...item 78 responds to social play	0--fail 1--pass
14...item 79 attempts to secure three cubes	0--fail 1--pass
15...item 80 rings bell imitatively	0--fail 1--pass
16...item 81 responds to name or nickname	0--fail 1--pass
17...item 82 says da-da or equivalent	0--fail 1--pass
18...item 83 uncovers toy	0--fail 1--pass
19...item 84 adjusts to words	0--fail 1--pass
20...item 85 fingers holes in peg board	0--fail 1--pass
21...item 86 puts cube in cup	0--fail 1--pass
22...item 87 looks for contents of box	0--fail 1--pass
23...item 88 attempts to imitate scribble	0--fail 1--pass
24...item 89 stirs with spoon in imitation	0--fail 1--pass
25...item 90 unwraps toy	0--fail 1--pass
26...item 91 pushes car along, imitatively	0--fail 1--pass
27...item 92 imitates words	0--fail 1--pass
28...item 93 uses expressive jargon	0--fail 1--pass
29...item 94 puts three or more blocks in cup	0--fail 1--pass
30...item 95 uncovers square box	0--fail 1--pass
31...item 96 dangles ring	0--fail 1--pass
32-53...Bayley Motor Scale Items[3]	
32...item 22 pulls to sitting while holding examiner's thumbs	0--fail 1--pass

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[3]Items 22-43 of the motor scales were selected for inclusion on the basis of a frequency distribution which revealed that only these items contained differences for the subjects sampled. Lower and higher item numbers were consistently passed or failed by all subjects of the sample.

Variable	Computer Code	
33...item 23 sits alone momentarily	0--fail	1--pass
34...item 24 reaches unilaterally	0--fail	1--pass
35...item 25 sits alone 30 seconds	0--fail	1--pass
36...item 26 sits alone steadily	0--fail	1--pass
37...item 27 rolls from back to stomach	0--fail	1--pass
38...item 28 secures pellet: radial raking	0--fail	1--pass
39...item 29 sits alone with good coordination	0--fail	1--pass
40...item 30 picks up cube: radial-digital grasp	0--fail	1--pass
41...item 31 prewalking progression	0--fail	1--pass
42...item 32 makes early stepping movements	0--fail	1--pass
43...item 33 secures pellet: inferior pincher grasp	0--fail	1--pass
44...item 34 pulls self to standing position holding examiner's thumbs	0--fail	1--pass
45...item 35 raises self to sitting position	0--fail	1--pass
46...item 36 pulls self to standing position	0--fail	1--pass
47...item 37 brings two objects together at midline	0--fail	1--pass
48...item 38 secures pellet: neat pincher grasp	0--fail	1--pass
49...item 39 makes stepping movements	0--fail	1--pass
50...item 40 walks with help	0--fail	1--pass
51...item 41 sits down	0--fail	1--pass
52...item 42 stands alone without support	0--fail	1--pass
53...item 43 walks alone	0--fail	1--pass
54...speed of response	0...4, where 0 indicates "very slow, does not approach objects at all" and 4 indicates "very fast, anticipates examiner's moves"	

Variable	Computer Code
55...intensity of response	0...4, where 0 indicates "very weak, does not look at or handle objects" and 4 indicates "very strong, manipulates objects with considerable force"
56...duration of response	0...4, where 0 indicates "attends to objects only briefly" and 4 indicates "spends long time with objects"
57...persistence in pursuit	0...4, where 0 indicates "very low, makes no attempt to get objects on own" and 4 indicates "very high, makes vigorous and frequent attempts to get objects on own"
58...intensity of social response	0...4, where 0 indicates "very weak, does not respond to initiation of social contact" and 4 indicates "very strong, overreacts to persons"
59...nature of social response	0...4, where 0 indicates "evading" and 4 indicates "inviting"
60...nature of response to mother	0...4, where 0 indicates "ignoring" and 4 indicates "demanding"
61...activity level	0...4, where 0 indicates "hypoactive" and 4 indicates "hyperactive"
62...variability in behavior ratings	0--no 1--yes
63...weight	to nearest .1 kg
64...head circumference	to nearest cm

Four Year Data

The third analysis, which included data collected at four years of age, evaluated the following 67 variables.

Variable	Computer Code	
1...Stanford-Binet IQ score	IQ score	
2...Stanford-Binet basal age	months	
3...Stanford-Binet ceiling age	months	
4-35...Stanford-Binet subtests[4]		
Year II		
4...#1--Three-Hole Form Board	0--fail	1--pass
5...#3--Identifying Parts of the Body	0--fail	1--pass
6...#5--Picture Vocabulary	0--fail	1--pass
7...#6--Word Combinations	0--fail	1--pass
Year II-6		
8...#1--Identifying Objects by Use	0--fail	1--pass
9...#3--Naming Objects	0--fail	1--pass
10...#4--Picture Vocabulary	0--fail	1--pass
11...#5--Repeating 2 Digits	0--fail	1--pass
Year III		
12...#2--Picture Vocabulary	0--fail	1--pass
13...#3--Block Building: Bridge	0--fail	1--pass
14...#4--Picture Memories	0--fail	1--pass
15...#6--Drawing a Vertical Line	0--fail	1--pass
Year III-6		
16...#1--Comparison of Balls	0--fail	1--pass
17...#3--Discrimination of Animal Pictures	0--fail	1--pass
18...#4--Response to Pictures: Level 1	0--fail	1--pass
19...#6--Comprehension I	0--fail	1--pass
Year IV		
20...#1--Picture Vocabulary	0--fail	1--pass
21...#2--Naming Objects from Memory	0--fail	1--pass
22...#3--Opposite Analogies I	0--fail	1--pass
23...#4--Pictorial Identification	0--fail	1--pass

[4]In the COLR study, an abbreviated form of the Stanford-Binet was used including only the subtests listed above at each year level.

Variable	Computer Code
Year IV-6	
24...#2--Opposite Analogies I	0--fail 1--pass
25...#3--Pictorial Similarities & Differences I	0--fail 1--pass
26...#5--Three Commissions	0--fail 1--pass
27...#6--Comprehension III	0--fail 1--pass
Year V	
28...#1--Picture Completion: Man	0--fail 1--pass
29...#3--Definitions	0--fail 1--pass
30...#4--Copying a Square	0--fail 1--pass
31...#6--Patience: Rectangles	0--fail 1--pass
Year VI	
32...#1--Vocabulary	0--fail 1--pass
33...#2--Differences	0--fail 1--pass
34...#4--Number Concepts	0--fail 1--pass
35...#5--Opposite Analogies II	0--fail 1--pass
36...line walk (heel to toe, two feet)	0--failed 2 trials 1--passed 1 trial 2--passed 2 trials
37...hopping (right foot)	0--failed 2 trials 1--passed 1 trial 2--passed 2 trials
38...hopping (left foot)	0--failed 2 trials 1--passed 1 trial 2--passed 2 trials
39...ball catch (caught with hands or arms)	0--failed 3 trials 1--passed 1 trial 2--passed 2 trials 3--passed 3 trials
40...Wallin Pegboard (right hand)	0--fail 1--pass
41...Wallin Pegboard (left hand)	0--fail 1--pass
42...circle copy	0--fail 1--pass
43...cross copy	0--fail 1--pass
44...square copy	0--fail 1--pass
45...bead stringing	0--fail 1--pass
46...Porteus Maze (#III)	0--fail 1--pass
47...Porteus Maze (#IV)	0--fail 1--pass

Variable	Computer Code
48...right eye dominant	0--no 1--yes
49...left eye dominant	0--no 1--yes
50...right hand dominant	0--no 1--yes
51...left hand dominant	0--no 1--yes
52...indeterminant handedness	0--no 1--yes
53...right leg dominant	0--no 1--yes
54...left leg dominant	0--no 1--yes
55...emotional reactivity	0...4, where 0 indicates "extremely flat" and 4 indicates "extremely unstable"
56...degree of irritability	0...4, where 0 indicates "extremely phlegmatic" and 4 indicates "extremely irritable"
57...degree of cooperation	0...4, where 0 indicates "extreme negativism" and 4 indicates "extremely suggestible"
58...degree of dependency	0...4, where 0 indicates "very self-reliant, refuses help, overt confidence" and 4 indicates "constant need for attention or help"
59...duration of attention span	0...4, where 0 indicates "attends to tasks very briefly" and 4 indicates "highly perseverative"
60...goal orientation	0...4, where 0 indicates "no effort to reach a goal" and 4 indicates "compulsive absorption with tasks"

Variable	Computer Code
61...response to directions	0...4, where 0 indicates "unwilling to follow specific directions" and 4 indicates "completely dependent upon specific directions"
62...level of activity	0...4, where 0 indicates "extreme inactivity and passivity, very little self-initiated activity" and 4 indicates "extreme over-activity and restlessness"
63...nature of activity	0...4, where 0 indicates "extreme rigidity, unable to shift activity or approach to task" and 4 indicates "extremely impulsive, explosive, and uncontrolled behavior"
64...nature of communication	0...4, where 0 indicates "nonverbal communication, uses gestures" and 4 indicates "content is usually irrelevant and inappropriate, may at times seem bizarre"
65...attending nursery school	0--no 1--yes
66...variability in behavior ratings	0--no 1--yes
67...mother worked during preschool period	0--no 1--yes

Seven Year Data

The final analysis included the following variables collected when the subjects were seven years old. Eighty variables were included at this stage of the study. The least significant variables (dropped after the initial computer run) are listed in the Appendix. The variables eliminated did not have significant F values at Step 0 and were dropped to allow additional variables to be analyzed. This procedure was utilized because of the limitations introduced by the computer's capacity.

Variable	Computer Code	
1-30...Bender Gestalt scoring categories (Koppitz system)		
1...1a--distortion	0--absent	1--present
2...1b--disproportion	0--absent	1--present
3...2--rotation	0--absent	1--present
4...3--integration	0--absent	1--present
Figure 1		
5...4--circles for dots	0--absent	1--present
6...5--rotation	0--absent	1--present
7...6--perseveration	0--absent	1--present
Figure 2		
8...7--rotation	0--absent	1--present
9...8--shape lost	0--absent	1--present
10...9--perseveration	0--absent	1--present
Figure 3		
11...10--circles for dots	0--absent	1--present
12...11--rotation	0--absent	1--present
13...12a--continuous line	0--absent	1--present
14...12b--lines for dots	0--absent	1--present
Figure 4		
15...13--rotation	0--absent	1--present
16...14--integration	0--absent	1--present
Figure 5		
17...15--circles for dots	0--absent	1--present
18...16--rotation	0--absent	1--present
19...17a--shape lost	0--absent	1--present
20...17b--lines for dots	0--absent	1--present
Figure 6		
21...18a--angles for curves	0--absent	1--present
22...18b--continuous line	0--absent	1--present
23...19--perseveration	0--absent	1--present
24...20--integration	0--absent	1--present
Figure 7		
25...21a--disproportion	0--absent	1--present
26...21b--distortion	0--absent	1--present
27...22--rotation	0--absent	1--present

Variable	Computer Code
Figure 7(Continued)	
28...23--integration	0--absent 1--present
Figure 8	
29...24--distortion	0--absent 1--present
30...25--rotation	
31...Bender error score	error score
32...WISC Verbal IQ score	IQ score
33...WISC Performance IQ score	IQ score
34...WISC Full Scale IQ score	IQ score
35...WISC Verbal-Performance discrepancy	scaled score points
36-44...WISC Subtest Scores[5]	
36...Information	scaled score
37...Comprehension	scaled score
38...Vocabulary	scaled score
39...Digit Span	scaled score
40...digits recalled forward	number of digits
41...digits recalled backward	number of digits
42...Picture Arrangement	scaled score
43...Block Design	scaled score
44...Coding	scaled score
45-47...Wide Range Achievement Test	
45...spelling grade level	grade level in months
46...arithmetic grade level	grade level in months
47...reading grade level	grade level in months
48...rapport with examiner	0...4, where 0 indicates "exceptionally shy, withdrawn" and 4 indicates "very self-confident"
49...level of frustration	0...4, where 0 indicates "withdraws completely" and 4 indicates "extreme acting out behavior and/or crying"

[5] In the COLR study, an abbreviated form of the WISC utilizing only the seven subtests listed above was administered.

Variable	Computer Code
50...duration of attention span	0...4, where 0 indicates "attends to tasks very briefly" and 4 indicates "highly perseverative"
51...goal orientation	0...4, where 0 indicates "no effort to reach a goal" and 4 indicates "compulsive absorption with task"
52...nature of communication	0...4, where 0 indicates "little or no verbal communication" and 4 indicates "difficult to follow child's thinking"
53...assertiveness	0...4, where 0 indicates "extremely assertive, willful personality" and 4 indicates "extreme passivity, malleability, and acquiescence to everything"
54...variability in behavior ratings	0--no 1--yes
55...weight	to nearest .1 kg
56...heart murmur	0--no 1--yes
57...spontaneous tremor	0--no 1--yes
58...intention tremor	0--no 1--yes
59...athetosis	0--no 1--yes
60...chorea	0--no 1--yes
61...right/left discrimination "Show me right hand." "Show me left eye." "Put right hand on left eye." "Put left hand on right ear."	0--failed 4 trials 1--passed 1 trial 2--passed 2 trials 3--passed 3 trials 4--passed 4 trials
62...right hand dominant	0--no 1--yes
63...left hand dominant	0--no 1--yes

Variable	Computer Code
64...indeterminant dominance	0--no 1--yes
65...right eye dominant	0--no 1--yes
66...left eye dominant	0--no 1--yes
67...right leg dominant	0--no 1--yes
68...left leg dominant	0--no 1--yes
69...abnormality in visual screening	0--no 1--yes
70...number of moves during child's first seven years	0....n
71-76...child's living arrangement since birth	
71...living with mother & father	0--no 1--yes
72...living with mother only	0--no 1--yes
73...living with father only	0--no 1--yes
74...living with other relative	0--no 1--yes
75...living with non-related person	0--no 1--yes
76...living arrangement has varied	0--no 1--yes
77...skin	0--normal 1--abnormal
78...mother worked during kindergarten & elementary years	0--no 1--yes
79...number in family	2....n
80...mixed dominance	0--no 1--yes

Several assumptions must be made regarding the variables which have just been listed and, in addition, about the subjects which were utilized in the study. For the variables under investigation, it was necessary to assume that several of the examinations conducted were reliable in the absence of any data confirming reliability. This assumption pertains especially to the neurological and pediatric examinations carried out by physicians and to the behavioral observations included in the various psychological evaluations. Since reliability data were not provided in the COLR study, for the purpose of the present study, it was assumed that some consistency in the ratings could be posited because many of the same individuals served as examiners throughout the years of the study. Admittedly, this is a major assumption but one considered necessary if credence is to be given to the results obtained in the current study.

In reference to the subjects selected for the study, the assumption made was that the learning disability diagnosis was accurate. Since the subjects had already been diagnosed within the school system and were not re-evaluated for the present study, there is the possibility that other examiners evaluating the same children would not concur in the learning disability diagnosis. In view of the lack of agreement regarding definition and description of the syndrome pointed out earlier, this possibility is particularly noteworthy. In this case, it is probably not safe to assume as before that some reliability may have been introduced because of the repeated participation of the same examiners. However, a standard diagnostic battery was utilized, and the tests administered do have well-established reliability and validity norms. Thus, some degree of error may be eliminated as a result.

Statistical Analysis

Four stepwise linear discriminant function analyses were computed in order to examine the differences between the learning disabled and the control groups. As noted in the previous section, the analyses were carried out for data collected at birth, at eight months, at four years, and at seven years. Thus, the variables under investigation differed at each age although similar kinds of variables were included in the different stages of the study. Scrutiny of the variables listed on the preceding pages illuminates these similarities. The discriminant function computed for each analysis was based upon a weighting system which maximized the variance between groups while minimizing the variance within groups (Cooley and Lohnes, 1962). In such an analysis, it is assumed that both the misclassification costs and the prior probabilities for each population are equal.

The analysis also demonstrated the order in which the variables were selected in discriminating between the groups at each age level. For example, the variable that contributed maximally to a prediction system already containing the best single predictor was chosen as the second predictor. An F test with g-1 and n-g-p degrees of freedom was employed at each stage to determine the predictor's contribution to the remaining variance within the system.

The criteria by which the best final predictors were selected are as follows:

(1) Because shrinkage typically occurs in this type analysis, the number of final predictors was limited to no more than the first six variables selected. This ceiling limit provided a subject to predictor ratio of 10:1.

(2) Final predictors were selected so that the number of misclassifications was at a minimum.

(3) Every variable in the final prediction system was required to reach significance at $p \leq .25$.

Following determination of the best predictors for each of the four analyses, a cross validation study was run utilizing 16 learning disabled and 16 control subjects in addition to the original 60 subjects. The cross validation phase provided information regarding the percent correct classification into groups on the basis of the predictors selected for each of the four stages of the study.

CHAPTER V

RESULTS

Introduction

The results for each of the four analyses conducted are presented in the following order in this chapter. For each analysis, there is a table showing the means, standard deviations, and F values obtained for each of the variables. Preceding this table, a discussion of the variables which show significant differences between the group means is presented. Secondly, the variables used in cross validation along with the manner in which they differentiate the groups are reported. Following this section, a table showing the number of cases classified into each group and the percent correct classification is provided. Finally, for the four and seven year analyses only, a table showing the variables with which the best predictors correlate significantly is included.

For each of the four analyses, a different number of variables is utilized in cross validation. The manner in which the specific number of variables was arrived at for each analysis is dependent upon three factors. These factors include: the F values to be removed, the approximate F value, and the percent correct classification shown for the two original groups. All three factors are evaluated at each step of the analysis, and the number of variables selected for cross validation is based upon that combination judged most capable of yielding the optimal percent correct classification in cross validation.

Birth Data

Table I presents the means, standard deviations, and F values for each of the 80 variables analyzed at birth. These data are provided at Step 0 of the discriminant function analysis and give information that is similar to that which might be obtained by running t tests. As shown in the table, nine of the 80 variables are significant at $p \leq .05$. The variables which did reach significance include whether the children's parents were separated at birth, the level of the father's education, and a number of judgments from the neurological examination. For the learning disabled children, the parents were more likely to be separated at the time of the child's birth. Likewise, the level of the father's education was lower for learning disabled than for control children.

All the neurological variables come from a group of data which evaluated muscle tonus. For each of five body segments (upper and lower extremities, neck flexor and extensor, and trunk), muscle tone was evaluated as hypotonic, normal, or hypertonic. (For analysis, a yes-no dichotomous scoring system indicated the state of the muscle group.) Seven of these variables reveal a significant difference between the group means. The results are surprising since all the variables of this group which do show a significant difference between the means vary in a direction opposite that which would be expected. For example, four variables evaluating normal muscle tonus reached significance, and for these variables the means for the learning disabled children are consistently higher than for the control children. This finding means that

TABLE I

MEANS, STANDARD DEVIATIONS, AND F VALUES
FOR BIRTH DATA

Variable	Learning Disability		Control		
	X̄	S.D.	X̄	S.D.	F
1...sex[a]	.233	.430	.200	.407	.095
2...parents married	.433	.504	.600	.498	1.659
3...parents divorced	.033	.183	.067	.254	.341
4...parents separated	.267	.450	.067	.254	4.500*
5...parents single	.200	.407	.167	.379	.108
6...parents common law	.067	.254	.033	.183	.341
7...parent widowed	.000	.000	.067	.254	2.071
8...birth order[b]	2.667	1.626	2.267	1.893	.771
9...number in family[b]	4.800	1.955	4.600	1.958	.157
10...nuclear family	.767	.430	.800	.407	.095
11...extended family	.233	.430	.233	.430	.000
12...level of mother's education (grade)[b]	9.567	2.046	10.233	2.388	1.349
13...level of father's education (grade)[b]	6.967	4.642	9.533	3.711	5.595*
14...mother primary caretaker	.733	.450	.767	.430	.086
15...other relative primary caretaker	.167	.379	.133	.346	.127
16...mother worked during pregnancy	.133	.346	.133	.346	.000
17...type of labor	.033	.183	.100	.305	1.055
18...rupture of membranes	.600	.498	.733	.450	1.184
19...vertex delivery	.967	.183	1.000	.000	1.000
20...Cesearean section	.033	.183	.000	.000	1.000

TABLE I (Continued)

Variable	Learning Disability $\bar{X}$	Learning Disability S.D.	Control $\bar{X}$	Control S.D.	F
21...duration of labor (minutes)[b]	319.900	212.221	299.433	156.650	.181
22...head controlled manually	.633	.490	.533	.507	.603
23...head controlled with forceps	.267	.450	.467	.507	2.610
24...head uncontrolled	.100	.305	.000	.000	3.222
25...placenta manually extracted & separated	.000	.000	.033	.183	1.000
26...placenta manually extracted only	.033	.183	.000	.000	1.000
27...condition of placenta	.967	.183	1.000	.000	1.000
28...cord pathology absent	.767	.430	.700	.466	.331
29...cord around neck	.133	.346	.267	.450	1.657
30...cord around body	.033	.183	.000	.000	1.000
31...cord around extremities	.000	.000	.033	.183	1.000
32...abnormal fetal heart rate	.067	.254	.167	.379	1.442
33...meconium and/or staining	.100	.305	.067	.254	.212
34...placental abnormalities	.067	.254	.000	.000	2.071
35...uterine stimulant used	.267	.450	.267	.785	.000
36...weeks gestation[b]	39.567	1.431	38.400	7.050	.789
37...birth weight (kg)[b]	29.400	5.550	33.267	9.670	3.608
38...head circumference (cm)[b]	34.567	3.812	34.933	3.638	.145
39...chest circumference (cm)[b]	32.167	4.308	31.767	4.344	.128
40...cyanosis	.200	.610	.133	.346	.271

TABLE I (Continued)

Variable	Learning Disability $\overline{X}$	Learning Disability S.D.	Control $\overline{X}$	Control S.D.	F
41...jaundice	.433	.504	.367	.490	.270
42...facies	.033	.183	.067	.254	.341
43...head normal	.600	.498	.633	.490	.068
44...normal respirations	.933	.254	.967	.183	.341
45...labored respirations	.067	.254	.033	.183	.341
46...shallow respirations	.033	.183	.067	.254	.341
47...skin	.233	.430	.267	.450	.086
48...heart murmur	.000	.000	.033	.183	1.000
49...heart normal	1.000	.000	.933	.254	2.071
50...heart rhythm irregular	.000	.000	.033	.183	1.000
51...moro obtained with ease	1.000	.000	.933	.254	2.071
52...moro obtained with difficulty	.000	.000	.033	.183	1.000
53...cry normal	.900	.305	.933	.254	.212
54...cry abnormal	.100	.305	.067	.254	.212
55...motor activity normal	.633	.490	.733	.450	.678
56...motor activity tremulous	.367	.490	.267	.450	.678
57...motor activity rapid, jerky	.033	.183	.000	.000	1.000
58...motor activity myoclonic	.100	.305	.000	.000	3.222
59...motor activity writhing	.033	.183	.000	.000	1.000
60...upper extremity hypotonic	.000	.000	.033	.183	1.000
61...upper extremity normal	.967	.183	.767	.430	5.495*

TABLE I (Continued

Variable	Learning Disability $\bar{X}$	Learning Disability S.D.	Control $\bar{X}$	Control S.D.	F
62...upper extremity hypertonic	.033	.183	.200	.407	4.191*
63...lower extremity hypotonic	.067	.254	.000	.000	2.071
64...lower extremity hypertonic	.100	.305	.167	.379	.563
65...neck flexor hypotonic	.000	.000	.067	.254	2.071
66...neck flexor normal	.967	.183	.767	.430	5.495*
67...neck flexor hypertonic	.033	.183	.167	.379	3.013
68...neck extensor hypotonic	.000	.000	.067	.254	2.071
69...neck extensor normal	.967	.183	.733	.450	6.931*
70...neck extensor hypertonic	.033	.183	.200	.470	4.191*
71...trunk hypotonic	.000	.000	.000	.000	.000
72...trunk normal	.967	.183	.800	.407	4.191*
73...trunk hypertonic	.033	.183	.200	.407	4.191*
74...diagnosis by weight	.100	.305	.000	.000	3.222
75...dysmaturity absent	.967	.183	.967	.183	.000
76...dysmaturity equivocal	.033	.183	.033	.183	.000
77...dysmaturity present	.000	.000	.000	.000	.000
78...normal infant	.800	.407	.867	.346	.468

TABLE I (Continued)

Variable	Learning Disability		Control		
	$\overline{X}$	S.D.	$\overline{X}$	S.D.	*F*
79...CNS defect	.000	.000	.033	.183	1.000
80...other congenital malformation	.200	.407	.100	.305	1.160

[a]Mean values for most of the variables listed in Table I are based upon a dichotomous scoring system using 0 and 1 to denote the following categories:

Variable 1 0--male 1--female
Variables 2-7, 10-11, 14-16, 19-20, 22-26, 28-35, 40-41, 43-46, 48-73, 75-80
0--no 1--yes or 0--absent 1--present
Variables 17, 18
0--spontaneous 1--induced
Variable 27 0--not intact 1--intact
Variables 42, 47
0--normal 1--abnormal
0--term 1--premature

More complete descriptions of variables and scoring are found in Chapter IV on pages 36-39.

[b]Mean values for these variables represent actual numerical values.

*$p \leq .05$.

the muscle tone of the learning disabled children was more likely to be judged as normal than was the tone of the control children for the same muscle group. At the same time, the data reveal that the control children were more likely to be judged hypertonic for the same muscle groups. As stated, these findings are puzzling. A partial explanation may be noted in the fact that only nine of the 80 variables analyzed at this stage of the study reached significance. This level of significance is not much greater than that to be expected by chance, and with so many variables included in the analysis some of the differences may be attributed to chance alone. Even so, the consistency of the neurological results presents questions not currently answerable. The complete listing of variables included in the final birth analysis is presented in Table I.

From the 80 variables just listed, five variables were selected for use in the cross validation study. An overall $\underline{F}$ test ($\underline{F} = 5.250$, $\underline{df} = 1,54$, $\underline{p} \leq .05$) indicates that the discriminant function containing these five predictors significantly differentiates the learning disabled group from the control group although with only 50% correct classification in cross validation. Table II shows the percent correct classification for both the original and cross validation studies.

The specific predictors selected and the order in which they enter the discriminant function are: tone of the neck extensor, if the child's parents were separated at the time of the child's birth, the level of the father's education, presence or absence of placental abnormalities at birth, and the manner in which the rupture of membranes occurred at birth. More precisely, for the learning disabled children, the tone of the neck extensor was more likely to be normal (a rather surprising

TABLE II

CASES CLASSIFIED INTO GROUPS AT BIRTH
AT STEP 5

Group	Learning Disability	Control	Percent Correct Classification
Learning Disability (original sample, N = 30)	21	9	70%
Control (original sample, N = 30)	4	26	87%
Learning Disability (cross validation sample, N = 16)	8	8	50%
Control (cross validation sample, N = 16)	8	8	50%

result as noted above), the child's parents were more often separated at the time of the child's birth, and the children's fathers tended to have fewer years of formal education than the children of the control group. In addition, the learning disabled children were more likely to have placental abnormalities at birth although the manner in which the membranes were ruptured prior to birth was more often spontaneous as opposed to induced for the control group members (again, a rather surprising result).

As noted, the discriminant function containing these predictors distinguished the groups with only 50% accuracy in cross validation. Stated differently, at this stage of the study, correct classification upon cross validation does not exceed that which would be expected upon the basis of chance probabilities. Thus, being able to predict at birth that a child may later be learning disabled, at least on the basis of these data, appears questionable. Table II presents the number of cases classified into groups for both the original and cross validation studies as well as the percent correct classification for each group in the original and cross validation analyses. As stated previously, chance factors appear to play a significant role in the analysis at this point of the study.

Eight Month Data

In Table III, the means, standard deviations, and $\underline{F}$ values for the 64 variables included in the eight month analysis are presented. Four of these variables, a number likely to be found by chance alone, are significant at $\underline{p} \leq .05$. The variables which do show significant differences in the group means at Step 0 are the children's response to

TABLE III

MEANS, STANDARD DEVIATIONS, AND F VALUES
FOR EIGHT MONTH DATA

Variable	Learning Disability		Control		
	$\overline{X}$	S.D.	$\overline{X}$	S.D.	F
1...Bayley basal age (months)[a]	6.733	8.743	6.533	8.087	.846
2...Bayley ceiling age (months)[a]	11.500	12.484	11.567	9.942	.052
3...item 68[b] pulls string, securing ring	.867	.346	.967	.183	1.962
4...item 69 enjoys sound production	.933	.254	.933	.254	.000
5...item 70 lifts cup by handle	.933	.254	.900	.305	.212
6...item 71 retains two cubes	.900	.305	.867	.346	.157
7...item 72 attends to scribbling	.967	.183	.967	.183	.000
8...item 73 looks for dropped object	.833	.379	.933	.254	1.442
9...item 74 manipulates bell with interest in details	.800	.407	.967	.183	4.191*
10...item 75 responds playfully to mirror	.900	.305	.733	.450	2.821
11...item 76 vocalizes four different syllables	.633	.490	.600	.498	.068
12...item 77 pulls string purposefully to secure ring	.700	.466	.533	.507	1.755
13...item 78 responds to social play	.800	.407	.800	.407	.000

TABLE III (Continued)

Variable	Learning Disability $\overline{X}$	Learning Disability S.D.	Control $\overline{X}$	Control S.D.	F
14...item 79 attempts to secure three cubes	.533	.507	.300	.466	3.441
15...item 80 rings bell imitatively	.567	.504	.333	.479	3.375
16...item 81 responds to name or nickname	.733	.450	.833	.379	.867
17...item 82 says da-da or equivalent	.567	.504	.733	.450	1.826
18...item 83 uncovers toy	.467	.507	.367	.490	.603
19...item 84 adjusts to words	.167	.379	.167	.379	.000
20...item 85 fingers holes in peg board	.267	.450	.200	.406	.363
21...item 86 puts cube in cup	.267	.450	.133	.346	1.657
22...item 87 looks for contents of box	.167	.379	.067	.254	1.442
23...item 88 attempts to imitate scribble	.100	.305	.000	.000	3.222
24...item 89 stirs with spoon in imitation	.033	.183	.000	.000	1.000
25...item 90 unwraps toy	.000	.000	.000	.000	.000
26...item 91 pushes car along, imitatively	.000	.000	.000	.000	.000
27...item 92 imitates words	.000	.000	.000	.000	.000

TABLE III (Continued)

Variable	Learning Disability $\overline{X}$	Learning Disability S.D.	Control $\overline{X}$	Control S.D.	F
28...item 93 uses expressive jargon	.000	.000	.000	.000	.000
29...item 94 puts three or more blocks in cup	.000	.000	.000	.000	.000
30...item 95 uncovers square box	.000	.000	.000	.000	.000
31...item 96 dangles ring	.000	.000	.033	.183	1.000
32...item 22[c] pulls to sitting while holding examiner's thumbs	.833	.379	.900	.305	.563
33...item 23 sits alone momentarily	.933	.254	1.000	.000	2.071
34...item 24 reaches unilaterally	.967	.183	1.000	.000	1.000
35...item 25 sits alone 30 seconds	.933	.254	1.000	.000	2.071
36...item 26 sits alone steadily	.933	.254	.833	.379	1.442
37...item 27 rolls from back to stomach	.867	.346	.867	.346	.000
38...item 28 secures pellet: radial raking	.633	.490	.800	.406	2.054
39...item 29 sits alone with good coordination	.900	.305	.800	.407	1.160
40...item 30 picks up cube: radial-digital grasp	.900	.305	.833	.379	.563

TABLE III (Continued)

Variable	Learning Disability $\overline{X}$	Learning Disability S.D.	Control $\overline{X}$	Control S.D.	F
41...item 31 prewalking progression	.767	.430	.833	.379	.406
42...item 32 makes early stepping movements	.800	.407	.800	.407	.000
43...item 33 secures pellet: inferior pincher grasp	.467	.507	.433	.504	.065
44...item 34 pulls self to standing position holding examiner's thumbs	.700	.466	.767	.430	.331
45...item 35 raises self to sitting position	.500	.509	.500	.509	.000
46...item 36 pulls self to standing position	.333	.479	.433	.504	.620
47...item 37 brings two objects together at midline	.233	.430	.367	.490	1.254
48...item 38 secures pellet: neat pincher grasp	.200	.407	.167	.379	.108
49...item 39 makes stepping movements	.167	.379	.300	.466	1.478
50...item 40 walks with help	.067	.254	.133	.346	.725
51...item 41 sits down	.067	.254	.067	.254	.000
52...item 42 stands alone without support	.067	.254	.000	.000	2.071

TABLE III (Continued)

Variable	Learning Disability $\bar{X}$	Learning Disability S.D.	Control $\bar{X}$	Control S.D.	F
53...item 43 walks alone	.167	.592	.100	.548	.205
54...speed of response[d]	2.933	.740	3.133	.681	1.186
55...intensity of response	3.133	.681	3.200	.610	.159
56...duration of response	2.900	.481	3.000	.263	1.000
57...persistence in pursuit	3.033	.809	3.033	.615	.000
58...intensity of social response	2.833	.699	3.100	.548	2.706
59...nature of social response	3.033	.718	2.933	.740	.282
60...nature of response to mother	2.933	.521	3.233	.504	5.140*
61...activity level	2.933	.640	3.133	.571	1.631
62...variability in behavior ratings	.667	.479	.633	.490	.071
63...weight (kg)[a]	76.533	18.039	87.100	7.746	8.690*
64...head circumference (cm)[a]	42.967	2.659	44.533	1.358	8.263*

[a]Mean values for these variables represent actual numerical values.

[b]Bayley Scales of Mental Development, scored 0--fail 1--pass

[c]Bayley Scales of Motor Development, scored 0--fail 1--pass

[d]Behavior profile items scored 0...4 as described in Chapter IV, pages 41-42.

*$p \leq .05$.

item 74 of the Bayley Scales of Mental Development, weight, head circumference, and the nature of the child's response to the mother. Item 74 from the Bayley scale measures the child's interest in a bell presented by the examiner. The item is scored "pass" if the child inspects the bell visually and shows interest in the object by manipulating it in various ways. The means obtained in the analysis show that the control group children more often passed this item than did the learning disabled children. Control subjects also exceeded the learning disabled subjects in both weight and head circumference. In addition, they received higher scores on the item of the behavior profile that measured the children's responses to their mothers. The higher scores indicate that the control subjects were more aware of their mothers' presence and more demanding of them.

For these data, six variables were utilized in cross validation. The overall $\underline{F}$ test ($\underline{F} = 6.765$, $\underline{df} = 1,53$, $\underline{p} \leq .05$) reveals that the discriminant function containing these six predictors significantly differentiates the learning disabled from the control subjects with somewhat greater accuracy in cross validation than that of the analysis on birth data. The percent correct classification for each group is presented in Table IV.

The six predictors selected for cross validation are presented in the order in which they enter the discriminant function. Weight of the children was the best discriminator with the learning disabled children weighing less than their matched controls. The second variable entering the discriminant function evaluated the child's response to the mother. For this variable, the learning disabled child was likely to be less responsive to the mother while the control child was more aware of the

TABLE IV

CASES CLASSIFIED INTO GROUPS AT EIGHT MONTHS
AT STEP 6

Group	Learning Disability	Control	Percent Correct Classification
Learning Disability (original sample, N = 30)	26	4	87%
Control (original sample, N = 30)	4	26	87%
Learning Disability (cross validation sample, N = 16)	10	6	63%
Control (cross validation sample, N = 16)	7	9	56%

mother's presence and more demanding of her. The third variable entering the discriminant function was measured by the Bayley scales: the learning disabled children as a group exceeded the performance of the control subjects in placing a cube into a cup following the examiner's example. As in the case of weight, the learning disabled children also measured less in head circumference than did the control subjects. The last two variables entering the discriminant function were also from the Bayley scales. In the first case, the learning disabled children tended to be more responsive to their mirror images than did the control subjects while learning disabled children performed less adequately than did controls on the Bayley item measuring communicative skills. This last item measured the child's repetitive use of a two-syllable sound (e.g., da-da) at any point during the examination.

As noted earlier, the discriminant function containing these variables was able to provide a somewhat higher percent correct classification than that obtained in the first analysis. However, in the cross validation study, percent correct classification is still low. Thus, ability to predict which children are later likely to be classified as learning disabled is still doubtful on the basis of the data analyzed at this stage of the study. Table IV presents the cases classified into groups and the percent correct classification for each group.

Four Year Data

In Table V, the means, standard deviations, and $\underline{F}$ values for the 67 variables analyzed at the four year level of the study are presented. Of the 67 variables included, seven are significant at $\underline{p} \leq .05$ at Step 0

TABLE V

MEANS, STANDARD DEVIATIONS, AND F VALUES
FOR FOUR YEAR DATA

Variable	Learning Disability		Control		
	$\bar{X}$	S.D.	$\bar{X}$	S.D.	F
1...Stanford-Binet IQ	106.567	11.399	93.700	9.538	.380
2...Stanford-Binet basal age	2.889	3.604	3.160	4.115	7.308*
3...Stanford-Binet Ceiling age	4.303	8.520	5.033	7.087	13.017*
4...Year II, 1[a] Three-Hole Form Board	.967	.183	1.000	.000	1.000
5...Year II, 3 Identifying Parts of the Body	1.000	.000	1.000	.000	.000
6...Year II, 5 Picture Vocabulary	1.000	.000	1.000	.000	.000
7...Year II, 6 Word Combinations	.967	.183	1.000	.000	1.000
8...Year II-6,1 Identifying Objects by Use	.967	.183	1.000	.000	1.000
9...Year II-6,3 Naming Objects	1.000	.000	1.000	.000	.000
10...Year II-6,4 Picture Vocabulary	1.000	.000	1.000	.000	.000
11...Year II-6,5 Repeating Two Digits	.833	.379	.967	.183	3.013
12...Year III, 2 Picture Vocabulary	.833	.379	.967	.183	3.013
13...III, 3 Block Building: Bridge	1.000	.000	.933	.254	2.071
14...Year III, 4 Picture Memories	.933	.254	1.000	.000	2.071

TABLE V (Continued)

Variable	Learning Disability $\bar{X}$	Learning Disability S.D.	Control $\bar{X}$	Control S.D.	F
15...Year III, 6 Drawing a Vertical Line	.833	.379	.867	.346	.127
16...Year III-6,1 Comparison of Balls	.533	.507	.733	.450	2.610
17...Year III-6,3 Discrimination of Animal Pictures	.700	.466	.833	.379	1.478
18...Year III-6,4 Response to Pictures	.500	.509	.767	.430	4.808*
19...Year III-6,6 Comprehension I	.200	.407	.667	1.124	4.569*
20...Year IV, 1 Picture Vocabulary	.167	.379	.233	.430	.406
21...Year IV, 2 Naming Objects from Memory	.533	.507	.767	.430	3.691
22...Year IV, 3 Opposite Analogies I	.233	.430	.300	.466	.331
23...Year IV, 4 Pictorial Identification	.167	.379	.367	.490	3.126
24...Year IV-6,2 Opposite Analogies I	.033	.183	.067	.254	.341
25...Year IV-6,3 Pictorial Similarities and Differences I	.167	.379	.233	.430	.406
26...Year IV-6,5 Three Commissions	.200	.407	.333	.479	1.349
27...Year IV-6,6 Comprehension III	.200	.407	.167	.379	.108
28...Year V, 1 Picture Completion: Man	.033	.183	.133	.346	1.962

TABLE V (Continued)

Variable	Learning Disability $\overline{X}$	Learning Disability S.D.	Control $\overline{X}$	Control S.D.	F
29...Year V, 3 Definitions	.067	.254	.200	.407	2.320
30...Year V, 4 Copying a Square	.033	.183	.000	.000	1.000
31...Year V, 6 Patience: Rectangles	.033	.183	.100	.305	1.055
32...VI, 1 Vocabulary	.033	.183	.000	.000	1.000
33...Year VI, 2 Differences	.033	.183	.000	.000	1.000
34...Year VI, 4 Number Concepts	.033	.183	.000	.000	1.000
35...Year VI, 5 Opposite Analogies II	.033	.183	.000	.000	1.000
36...line walk[b]	1.767	.568	1.833	.461	.249
37...right foot hop	1.733	.691	1.567	.817	.727
38...left foot hop	1.567	.871	1.500	.938	.086
39...ball catch	1.600	1.070	2.033	.928	2.807
40...pegboard-right	.933	.254	1.000	.000	2.071
41...pegboard-left	.933	.254	1.000	.000	2.071
42...copy circle	1.000	.000	.967	.183	1.000
43...copy cross	.400	.498	.600	.498	2.417
44...copy square	.033	.183	.100	.305	1.055
45...bead stringing	.967	.183	1.000	.000	1.000
46...Porteus Maze III	.533	.507	.733	.450	2.610
47...Porteus Maze IV	.200	.407	.333	.479	1.349

TABLE V (Continued)

Variable	Learning Disability $\overline{X}$	Learning Disability S.D.	Control $\overline{X}$	Control S.D.	F
48...right eye dominant	.500	.509	.700	.466	2.522
49...left eye dominant	.500	.509	.300	.466	2.522
50...right hand dominant	.767	.430	.933	.254	3.341
51...left hand dominant	.067	.254	.033	.183	.341
52...handedness indeterminant	.167	.379	.033	.183	3.013
53...right leg dominant	.867	.346	.967	.183	1.962
54...left leg dominant	.133	.346	.033	.183	1.962
55...emotional reactivity[c]	3.000	.830	2.967	.615	.031
56...degree of irritability	3.167	.747	3.000	.587	.924
57...degree of cooperation	2.867	.819	3.000	.455	.607
58...degree of dependency	3.300	.877	3.100	.662	.994
59...duration of attention span	2.533	.629	2.867	.346	6.473*
60...goal orientation	2.600	.563	3.000	.000	15.131*
61...response to directions	2.967	.809	3.000	.455	.039
62...level of activity	3.233	.858	2.833	.592	4.414*
63...nature of activity	2.833	.747	2.900	.305	.205
64...nature of communication	2.833	.648	2.800	.664	.039
65...attends nursery school	.200	.484	.167	.592	.057
66...variability in behavior ratings	.833	.379	.700	.466	1.478

TABLE V (Continued)

Variable	Learning Disability		Control		
	$\overline{X}$	S.D.	$\overline{X}$	S.D.	F
67...mother worked during preschool period	.800	.407	.833	.379	.108

[a]Stanford-Binet subtests scored 0--fail 1--pass

[b]Items 36-54 scored 0--fail 1--pass or 0--no 1--yes

[c]Items 55-64 behavior profile items scored 0...4 as described in Chapter IV, pages 45-46.

$^{*}p \leq .05$

of the analysis. The significant variables include both basal and ceiling age on the Stanford-Binet. For these scores, the group means for the learning disabled children were lower than those of the control subjects. Two other Stanford-Binet variables also reached significance. Two subtests at the III-6 year level, one measuring the child's verbal response to pictures (subtest 4) and the other measuring the child's comprehension of basic concepts (subtest 6), also have significant F values. Learning disabled children scored lower on these subtests than did their matched controls. The remaining three variables showing significantly different group means are from the behavioral profile. On the items assessing the child's goal orientation and duration of attention span, the learning disabled children scored lower. These scores indicate that as a group the learning disabled children were more distractible and evinced less sustained activity toward achieving a goal. On the item evaluating level of activity, the learning disabled subjects scored higher than control subjects; thus, the learning disabled children more often exhibited restlessness and inability to sit quietly than did control subjects. Again, the number of significant variables is not great at Step 0, and because of the number of variables involved, some may be significant by chance.

At this level, two variables were selected for cross validation. The overall F test ($F = 13.360$, $df = 1,57$, $p \leq .05$) reveals that the discriminant function with two predictors significantly differentiates the learning disabled from the control group with still greater accuracy than at the two previous stages of the study. This statement is particularly true for the control group although correct classification is not as good for the learning disabled group.

Goal orientation and Stanford-Binet ceiling age are the variables used in cross validation. Goal orientation purports to measure the child's ability to keep the directions of a task in mind and to perform independently without repeated encouragement from the examiner. On this variable, the learning disabled subjects' scores reveal that these children generally made either fewer attempts or more sporadic attempts to carry out instructions while control subjects showed less need to have instructions repeated and encouragement offered. In other words, control subjects as a group were more likely to attempt completing a task on their own. Control subjects were also more likely to have higher ceiling levels on the Stanford-Binet than were learning disabled children. With these two variables, there was additional increase in the percent correct classification for the two groups in a cross validation study. Table VI gives the cases classified into each group for the original and cross validation studies and the percent correct classification for each group. Examination of the table reveals that the major increase in accuracy in classifying cases occurs for the control group while percent correct classification for learning disability groups is low in both the original and cross validation studies. Chance results again appear to be a factor at this stage of the study.

Table VII presents the variables which correlate significantly with the two best predictors of the four year data. The correlations are significant at $\underline{p} \leq .05$ or beyond.

Seven Year Data

The means, standard deviations, and $\underline{F}$ values for the seven year data are shown in Table VIII. Perusal of the table's contents reveals

TABLE VI

CASES CLASSIFIED INTO GROUPS AT FOUR YEARS AT STEP 2

Group	Learning Disability	Control	Percent Correct Classification
Learning Disability (original sample, N = 30)	18	12	60%
Control (original sample, N = 30)	4	26	87%
Learning Disability (cross validation sample, N = 16)	11	5	69%
Control (cross validation sample, N = 16)	3	13	81%

TABLE VII

SIGNIFICANT CORRELATIONS OF BEST PREDICTORS
WITH OTHER VARIABLES

	Goal Orientation	Stanford-Binet Ceiling Age
2...Stanford-Binet basal age	----	.435
4...Year II, 1 Three-Hole Form Board	----	.648
21...Year IV, 1 Picture Vocabulary	----	.369
22...Year IV, 3 Opposite Analogies I	.270	----
27...Year IV-6, 6 Comprehension III	----	.392
28...Year V, 1 Picture Completion: Man	----	.284
29...Year V, 3 Definitions	----	.402
36...line walk	.351	----
40...Wallin pegboard/right hand	----	.381
41...Wallin pegboard/left hand	.290	----
61...response to directions	.435	----

TABLE VIII

MEANS, STANDARD DEVIATIONS, AND F VALUES FOR SEVEN YEAR DATA

Variable	Learning Disability		Control		
	$\bar{X}$	S.D.	$\bar{X}$	S.D.	F
1...Figure A[a] distortion	.500	.509	.467	.507	.065
2...Figure A disproportion	.167	.379	.100	.305	.563
3...Figure A rotation	.467	.507	.133	.346	8.842**
4...Figure A integration	.300	.466	.300	.466	.000
5...Figure 1 circles for dots	.233	.430	.133	.346	.985
6...Figure 1 rotation	.133	.346	.000	.000	4.462*
7...Figure 1 perseveration	.267	.450	.200	.407	.363
8...Figure 2 rotation	.033	.183	.067	.254	.341
9...Figure 2 shape lost	.100	.305	.033	.183	1.055
10...Figure 2 perseveration	.200	.407	.167	.379	.108
11...Figure 3 circles for dots	.267	.450	.233	.430	.086
12...Figure 3 rotation	.267	.450	.167	.379	.867
13...Figure 3 continuous line	.400	.498	.267	.450	1.184
14...Figure 3 shape lost	.067	.254	.000	.000	2.071

TABLE VIII (Continued)

Variable	Learning Disability $\bar{X}$	Learning Disability S.D.	Control $\bar{X}$	Control S.D.	F
15...Figure 4 rotation	.533	.507	.400	.498	1.055
16...Figure 5 integration	.533	.507	.467	.507	.259
17...Figure 5 circles for dots	.133	.346	.267	.450	1.657
18...Figure 5 rotation	.500	.509	.500	.509	.000
19...Figure 5 shape lost	.167	.379	.067	.254	1.442
20...Figure 5 lines for dots	.100	.305	.067	.254	.212
21...Figure 6 angles for curves	.500	.509	.367	.490	1.069
22...Figure 6 continuous line	.067	.254	.000	.000	2.071
23...Figure 6 perseveration	.100	.305	.000	.000	3.222
24...Figure 6 integration	.567	.504	.367	.490	2.428
25...Figure 7 disproportion	.167	.379	.233	.430	.406
26...Figure 7 distortion	.900	.305	.967	.183	1.055
27...Figure 7 rotation	.567	.504	.367	.490	2.428
28...Figure 7 integration	.533	.507	.400	.498	1.055
29...Figure 8 distortion	.933	.254	.933	.254	.000

TABLE VIII (Continued)

Variable	Learning Disability $\bar{X}$	Learning Disability S.D.	Control $\bar{X}$	Control S.D.	F
30...Figure 8 rotation	.167	.379	.067	.254	1.442
31...Bender error score[b]	9.767	3.980	7.733	2.791	5.249*
32...WISC Verbal IQ	83.500	8.464	93.560	7.614	23.612**
33...WISC Performance IQ	86.433	13.016	97.200	9.827	13.074**
34...WISC Full Scale IQ	83.560	9.294	94.900	7.549	26.718**
35...WISC verbal-performance discrepancy	11.533	7.319	9.467	5.588	1.511
36...Information scaled score	7.567	1.755	9.567	1.357	24.381**
37...Comprehension scaled score	8.133	2.129	8.467	2.080	.376
38...Vocabulary scaled score	6.033	1.902	7.600	2.238	8.536**
39...Digit Span scaled score	7.800	2.441	10.133	2.193	15.169**
40...digits recalled forward	4.467	.860	5.167	1.052	7.948**
41...digits recalled backward	1.467	1.306	2.400	.968	9.885**
42...Picture Arrangement scaled score	6.933	1.981	9.067	2.406	14.054**
43...Block Design scaled score	7.400	2.568	9.700	2.168	14.053**
44...Coding scaled score	9.833	3.052	9.933	2.703	.018
45...WRAT spelling grade level	1.2--	2.788	1.9--	6.320	29.358**
46...WRAT arithmetic grade level	1.1--	5.097	1.9--	3.385	48.334**
47...WRAT reading grade level	1.1--	4.747	2.0--	6.628	35.224**
48...rapport with examiner[c]	2.833	.461	2.633	.556	2.300

TABLE VIII (Continued)

Variable	Learning Disability		Control		
	$\overline{X}$	S.D.	$\overline{X}$	S.D.	F
49...level of frustration	2.633	.490	2.767	.430	1.254
50...duration of attention span	2.900	.403	3.133	.434	4.659*
51...goal orientation	2.933	.365	3.100	.305	3.680
52...nature of communication	2.467	.507	2.633	.490	1.674
53...assertiveness	3.167	.461	3.467	.507	5.743*
54...variability in behavior ratings[d]	.833	.379	.733	.521	.723
55...weight (kg)[b]	233.933	28.934	223.067	34.242	1.763
56...heart murmur	.133	.346	.000	.000	4.462*
57...spontaneous tremor	.000	.000	.000	.000	.000
58...intention tremor	.000	.000	.000	.000	.000
59...athetosis	.033	.183	.000	.000	1.000
60...chorea	.000	.000	.000	.000	.000
61...right/left discrimination (4 trials)	2.533	1.717	3.667	.959	9.966**
62...right hand dominant	.933	.254	.967	.183	.341
63...left hand dominant	.067	.254	.033	.183	.341
64...indeterminant dominance	.000	.000	.000	.000	.000
65...right eye dominant	.667	.479	.667	.479	.000
66...left eye dominant	.333	.479	.333	.479	.000
67...right leg dominant	.933	.254	.900	.305	.212
68...left leg dominant	.067	.254	.100	.305	.212
69...abnormality in visual screening	.600	.498	.600	.498	.000

TABLE VIII (Continued)

Variable	Learning Disability $\bar{X}$	Learning Disability S.D.	Control $\bar{X}$	Control S.D.	*F*
70...number of moves during first 7 years[b]	1.833	1.117	2.333	1.583	1.999
71...living with mother & father since birth	.467	.507	.467	.507	.000
72...living with mother only since birth	.433	.504	.400	.498	.066
73...living with father only since birth	.000	.000	.000	.000	.000
74...living with other relative since birth	.033	.183	.033	.183	.000
75...living with non-related person since birth	.000	.000	.000	.000	.000
76...living arrangement since birth has varied	.067	.254	.067	.254	.000
77...skin[e]	.100	.305	.167	.379	.563
78...mother worked during kindergarten & elementary years	.767	.430	.833	.379	.406
79...number in family[b]	6.367	2.266	6.600	6.790	.032
80...mixed dominance	.367	.490	.367	.490	.000

[a]Bender Gestalt scoring categories, scored 0--fail 1--pass.

[b]Mean scores presented are actual numerical values for variables 31-47 and variables 55, 70, 79.

[c]Items for behavior profile scored 0...4 as described in Chapter IV, pages 48-49 (variables 48-53).

[d]Mean values presented for variables 54, 56-60, 62-69, 71-76, 78, and 80 based on a dichotomous scoring system where 0--no 1--yes.

[e]Variable 77 scored 0--normal 1--abnormal.

*$p \leq .05$
**$p \leq .01$

that of the 80 variables included in the final analysis at this age, 20 reach significance at Step 0. The 20 variables showing statistically significant differences between the means can be grouped into four major categories. The first category is composed of information obtained from the Bender Gestalt Test. The group means reveal that a rotation on either Figure A or Figure 1 occurred more frequently among the learning disabled subjects. In addition, the learning disabled children had higher overall error scores on the Bender.

The second major area in which significant differences between the means of the two groups are found is seen among the intellectual and academic measures used. For the learning disabled subjects, the group means for WISC Verbal, Performance, and Full Scale IQ scores are approximately 10 points below the means of the control group. Other significant differences are observed between the means of the learning disabled and control groups on the following WISC subtests: Information, Vocabulary, Digit Span, Picture Arrangement, and Block Design. On these subtests, the means for the learning disabled children are lower than those obtained for the control group members. In addition, the learning disabled children recalled a fewer number of digits forward and backward than did the control subjects. The academic measures included are from the Wide Range Achievement Test (WRAT). For the three areas evaluated by this instrument, reading, spelling, and arithmetic, the mean grade level of the control subjects exceeds that for the learning disabled subjects.

The third major category in which significant differences are observed for the two groups is in several ratings of the behavior profile. The learning disabled children have group means showing that they tended to have shorter attention spans and to be less assertive than the control group members. The final variables showing a significant difference between the group means are from the neurological examination. Learning disabled children were less successful in making right/left discriminations and also were more likely to have a heart murmur detected upon examination.

A significant difference between the means of this many of the 80 variables analyzed is greater than the number that would be anticipated on the basis of chance alone. Thus, for the data at Step 0 of the seven year analysis, there appears to be a much better means of differentiating the two groups than is seen at the three earlier stages of the study.

For the seven year analysis, four variables were selected for use in cross validation. The overall $\underline{F}$ ($\underline{F}$ = 28.691, $\underline{df}$ = 1,55, $\underline{p} \leq .001$) indicates that the discriminant function containing these four predictors significantly differentiates the learning disabled from the control group at a level much greater than chance. The variables used in cross validation include: WRAT arithmetic grade level, the child's assertiveness and nature of communication, and WRAT spelling grade level. The order listed is that in which the variables enter into the discriminant function. The specific manner in which these variables differentiate the two groups is as follows. Learning disabled children scored lower on both the WRAT measures. In addition, they were more likely to receive lower ratings than the control subjects on the two items from the behavior profile. On the item purporting to assess the child's assertiveness, the learning disabled children were usually judged more passive and acquiescent to the examiner's wishes in the testing situation. On the other hand, control subjects were more assertive and demanding of the examiner. In regard to the nature of the children's communication, the learning disabled children were more likely to be non-verbal or to respond only to direct questions while control group member members revealed more spontaneous speech and were likely to elaborate much more than the learning disabled children in response to test questions.

Table IX presents the cases classified into each group and the percent correct classification for the groups in the original and cross validation analyses. As the table evinces, the percent correct classification again exceeds that expected by chance.

TABLE IX

CASES CLASSIFIED INTO GROUPS AT SEVEN YEARS AT STEP 4

Group	Learning Disability	Control	Percent Correct Classification
Learning Disability (original sample, N = 30)	26	4	87%
Control (original sample, N = 30)	0	30	100%
Learning Disability (cross validation sample, N = 16)	11	5	69%
Control (cross validation sample, N = 16)	6	10	63%

In Table X, the variables which correlate significantly with the best predictors selected for the seven year data are shown. Correlations are significant at $p \leq .05$ or beyond.

TABLE X

SIGNIFICANT CORRELATIONS OF BEST PREDICTORS WITH OTHER VARIABLES

	WRAT Arithmetic Grade Level	Asser-tiveness	Nature of Communication	WRAT Spelling Grade Level
8...Figure 2 rotation	----	.306	----	----
25...Figure 7 disproportion	----	.254	----	----
26...Figure 7 distortion	----	----	.279	----
27...Figure 7 rotation	----	.289	----	----
32...WISC Verbal IQ	.335	----	.385	----
33....WISC Performance IQ	.350	----	----	----
34...WISC Full Scale IQ	.426	----	.329	----
36...Information scaled score	----	----	----	.251
37...Comprehension scaled score	.293	----	----	----
38...Vocabulary scaled score	----	----	.302	----
41...Number of digits recalled backward	----	----	.267	----
42...Picture Arrangement scaled score	.323	----	----	----
43...Block Design scaled score	.317	----	----	----
45...WRAT spelling grade level	.312	----	----	1.000

TABLE X (Continued)

	WRAT Arithmetic Grade Level	Asser-tiveness	Nature of Communication	WRAT Spelling Grade Level
46...WRAT arithmetic grade level	1.000	----	----	.312
47...WRAT reading grade level	.343	----	----	.795
48...rapport with examiner	----	----	.629	----
49...level of frustration	----	----	.267	----
54...variability in behavior ratings	----	.435	----	----
63...left hand dominant	----	----	----	.281
65...right eye dominant	----	----	----	.270
71...child living with mother and father since birth	----	.430	----	----

CHAPTER VI

DISCUSSION

Perusal of the results obtained in the analysis reveals that the ability to differentiate the learning disabled students from the successful students increases with age. Not only does the number of variables significant at Step 0 tend to increase but, in general, the trend is for the percent correct classification in both the original and cross validation studies to improve also. Thus, for the variables included in this study, it is not until the ages of four and seven years that the distinction between learning disabled and control subjects can be made very accurately. In fact, it is actually the seven-year data that contains the largest number of significant variables at Step 0. However, the percent correct classification in cross validation for the four-year data is high enough that actual differences between the groups appear to be measured at this age also. For the data analyzed at birth and at eight months, the significant differences and the correct classification upon cross validation are both low; in fact, the number of variables significant at Step 0 and the percent correct classification upon cross validation, although generally somewhat better than one would expect by chance, are still not impressive. In the case of the birth data, the percent correct classification in the cross validation study does not exceed the level that is anticipated by chance at all. It would appear then, at least on the basis of these data, that it is not possible to predict with accuracy beyond a chance level which children will experience learning problems until near the time for a child to enter school.

Even though prediction may be minimally accurate at the early ages in this study, it is possible that factors inherent in the design of the study may preclude more adequate early prediction. These factors are specifically related to the data utilized. The reader is reminded of the assumptions discussed in Chapter IV. Because data that had previously been collected were used, it was necessary simply to assume that many of the assessments made by individual examiners were reliable. This assumption was required particularly in the case of variables taken from the neurological and behavioral evaluations. Although guidelines relevant to these examinations were provided for the examiners involved in the COLR study, there are no established reliability data as there are for some of the psychological instruments used at the later stages of the study. It was also noted in Chapter IV that a number of different examiners were utilized in the COLR study without any data on inter-rater reliability. Even though the same primary examiners were used over the years, the fact that no data on inter-rater reliability were collected made it necessary simply to assume that the ratings were reliable.

A further assumption necessitated by the design of the study was that the accuracy of the learning disability diagnosis could be accepted. The reader will remember that the children included in the study's learning disability group had been tested and diagnosed within the school system. The children were not re-evaluated for the study, and the diagnosis was accepted at face value. Since a standard diagnostic battery with well-documented reliability and validity norms was used, it was hoped that the possibility of misdiagnosis would be minimal. However, judging from the seven year data this assumption is at least open to question. As noted in the previous chapter, the means for the learning disabled and control subjects were significantly different for all three WISC IQ scores. On each of these IQ variables, the means for the learning disabled children measured about 10 points below those for the control subjects. These scores place the learning disabled children within Wechsler's category of "dull normal" intelligence while the control subjects' IQ scores as a group were within the range from 90-99. Other studies (e.g., Rourke et al., 1975) have used a similarly broad range of scores although in these studies both the learning disabled and control subjects have had IQ scores spread throughout the range from 80-120. It is the discrepancy between the scores of the learning disabled and control subjects found here that provokes questions regarding the learning disabled/nondisabled dichotomy.

These points are noted to emphasize that factors other than the specific variables selected for study may have contributed a confounding effect upon the results of the study. One additional problem with the design of the study derived from the fact that data already collected were used. Thus, no data were available for the ages between eight months and four years. Keeping in mind that the assumptions made at the outset of the study appear to be open to question and that a variety of error sources may have influenced the obtained findings as a result, there are still a number of relationships which deserve discussion. In addition, there are findings which appear to merit further investigation under more adequately controlled conditions. These points will be discussed below as the general nature of the results from the previous chapter are reviewed and elaborated.

For the data analyzed both at birth and at eight months, the possibility is strong that the factors discussed above exert a confounding effect. In the case of the neurological assessments and the behavioral observations, this possibility is particularly likely. In addition, the nature of the results obtained reveals that chance factors may play a significant role in the early stages of the study. This statement is based upon the following observations. The number of variables significant at Step 0 for both ages is barely beyond the number expected to be significant by chance alone. Also, the percent correct classification for the cross validation studies is low. For the birth data, this percent is no greater than chance and only slightly greater at eight months. Furthermore, there are a number of results which simply are not capable of being explained upon any basis other than chance. Thus, as already stated, distinction between the group members and therefore prediction appears to be highly questionable at the early stages of the study.

For the four and seven year data, prediction appears more feasible. The seven variables significant at Step 0 in the four year analysis can be easily separated into two groups. The first four variables which discriminate between the learning disabled and control subjects at a significant level are from the Stanford-Binet. Learning disabled subjects scored lower on all four Binet variables, including basal and ceiling ages and the "Comprehension I" and "Response to Pictures" subtests. An explanation for these results is not immediately obvious although it is possible that the four Binet variables reflect the learning disabled child's difficulty in regard to verbal expressive or integrative skills. The two subtests which evince a significant difference in the group means both require more extensive verbal responses than most of the other subtests included. The subtests below this level require either a pointing response or some other form of specific activity, and on these subtests no significant differences were found. The other subtests tapping a verbal expressive skill occur at a level that is beyond the ceiling ages for both groups. Consequently, differences could not be registered.

The second group of variables fits into a pattern of behavior which has been described and discussed repeatedly in studying learning disabled children. Three items from the behavior profile used at this age reveal that the learning disabled students showed characteristics very similar to those commonly cited as typical of many learning disabled children. According to Clarkson and Hayden (1972), descriptors denoting impulsivity, distractibility, hyperactivity, unpredictability, and explosiveness are the most frequently occurring terms in the written descriptions of recognized authorities in the field. In this study, at the four year level the learning disabled children did tend to have shorter attention spans and to be less able to sustain goal-directed activity. At the same time, they were more restless and less able to sit still for extended periods of time within the testing situation, an academically-oriented situation likely to be a source of pressure for many of the children.

For the data analyzed at seven years, it is immediately obvious that the ability to distinguish the members of the two groups is much greater than at the three earlier ages. This statement is especially true of the Step 0 data. Although there is also a greater percent correct classification upon cross validation, the results are not as impressive as for the data obtained at Step 0 and in the classification step of the original analysis. Nevertheless, at this stage in the study, chance factors seem much less likely to be involved in the results obtained. Since some of the variables included in the analysis are ones from the test battery used in classifying the groups, significant differences would more readily be expected, and in fact, were found. To facilitate discussion, the variables of the seven year analysis will be considered in two groupings, those variables included in the initial diagnostic battery and those not included. When considered in this manner, the results at seven years seem less impressive. Nevertheless, the distinction is an important one.

The variables which comprised a portion of the diagnostic battery are from the Bender Gestalt Test, the WISC, and the WRAT. Consistent with a number of previous studies (Koppitz, 1964; deHirsch, 1966; Ames, 1969) the present data reflect less proficient performance on the Bender Gestalt Test for the learning disabled children. However, since only three of 31 variables from the Bender reached significance and additionally the Bender was included in the original diagnostic battery, the results are not impressive. This finding is really more consistent with the conclusion drawn by Ackerman et al. (1971), who stated that Bender results are "not very impressive" as a means of distinguishing learning disabled from successful school children.

Most of the WISC data analyzed in this study reveal significant differences between the two groups. Again, this instrument is one of those used to establish the criterion groups. Since the IQ scores for learning disabled children were generally 10 points below those of the control subjects, some of the differences in individual subtest scores may be an artifact of the overall differential in performance. Furthermore, an abbreviated form of the WISC was used in the COLR study with some of the subtests which have reflected differences between learning disabled and control subjects in previous studies not presently included. The arithmetic subtest, which has repeatedly appeared as an area of less adequate performance among disabled readers (Heulsman, 1970) is a good example. Other subtests not included were Object Assembly, Picture Completion, and Similarities. These three subtests have also featured prominently in the results of many studies examining WISC patterning. Rugel's review and reclassification of WISC studies (1974) provides an example. Picture Completion and Object Assembly were both used to assess a spatial category while Similarities figured in a conceptual category and Picture Arrangement in a sequential category (from Bannatyne, 1968). When studies using the WISC were reconsidered in this manner, learning disabled subjects showed a consistent pattern of performance: spatial $>$ conceptual $>$ sequential. Because of the overall IQ differences and the omission of key subtests, the results from Rugel's study and from other studies cannot be confirmed.

In regard to results obtained from analyzing the WISC data, the significant points seem to be that the learning disabled subjects had overall lower IQ scores and did not evince significant differences on either the Comprehension or Coding subtests in spite of this differential in IQ scores. Also of note is the fact that learning disabled subjects did not show any greater range of scatter than did the controls. In addition, discrepancy between verbal and performance IQ scores did not differentiate the groups.

The third segment of the significant variables which also comprised a portion of the diagnostic battery originally used to identify learning disabled students were WRAT grade levels. Learning disabled children scored lower on each of the three grade levels, reading, spelling, and arithmetic. However, their scores were only from seven to nine months below those of the control subjects rather than being one to two years below expected grade level. Considered concomitantly with the WISC data, these results raise some question regarding the accuracy of the learning disability diagnosis for the children included in the study.

The second major grouping consisting of those variables not included in the diagnostic battery for determining learning disability is composed of four apparently unrelated variables. Two are from the behavior profile and two from the seven year pediatric-neurological examination. Consistent with the four year finding, the learning disabled children at seven years evinced shorter attention spans. In addition, they were judged less assertive, more frequently had heart murmurs, and were less capable of making right/left discriminations.

Since different variables were analyzed at each of the four different age levels, it is actually not surprising that more consistent results were not obtained. However, it is the limiting factors inherent in the data that make the general conclusions which can be drawn rather limited in scope. That the reliability of some of the data is open to question and that the accuracy of the learning disability diagnosis itself is questionable impose obvious limitations upon interpretation of the data. Furthermore, the entire sample was composed of black youngsters from a lower socioeconomic status background. The latter point is of importance since at least one survey (Franks, 1971) has shown that the majority of children in learning disability classes have traditionally been white middle class students. The relationship between socioeconomic status and learning disabilities has not been thoroughly researched although Teledgy (1973) has published one study in which the performance of lower and middle class learning disabled children was comparable on the WISC. Both Grotberg (1970) and Leton (1972) argue that the composition of learning disabled and culturally disadvantaged groups is not mutually exclusive while Johnson and Myklebust (1967) emphasize that without competent screening and objective criteria, it is difficult to distinguish specific learning disabilities from cultural deprivation.

In spite of these points, there are several important features observed in the current findings. First, it appears that attempts at early prediction may not be successful before four or five years of age if variables of the nature included in the study are used. The results reveal that it may be necessary for a child to have developed some of the language skills which mediate school success before very accurate prediction can occur. Furthermore, the current study indicates that behavioral measures may be particularly useful in distinguishing learning disabled from successful school children. In this study, it was the behavioral measures which revealed the most consistent finding of the study, that is, that learning disabled children have difficulty with the attentional process for academic information. The importance of both language skills and attention in discriminating between learning disabled and successful school children has recently been noted by Bryan (1974). She contends that learning disabilities can most easily be distinguished on the basis of tasks which make heavy demands on language skills and upon the attentional process. Both findings are generally supported in the current study.

The previous statements apply to the data given the assumption that the children included in the study are actually learning disabled. However, it has already been noted that both the intellectual and academic variables raise some question about the diagnosis made in the school system. Since there is a 10-point discrepancy between the learning disabled and control subjects' IQ scores, it is possible that the children labeled learning disabled are actually a heterogeneous group of "slow learners" suffering additionally from cultural disadvantage. The fact that the WRAT scores do not reflect a larger discrepancy between the academic levels of the learning disabled and control subjects also supports this possibility. Mention is made of this point not only because of the implications for interpretation of the study's findings but also because of the possibility that the burgeoning interest in learning disabilities has led to overuse of an otherwise beneficial diagnostic label. In relation to the latter point, it is also important to note that the absence of evidence establishing a single "learning disability syndrome" makes the variety of learning problems that children experience a further obstacle to accurate early identification at this point in time. Again, this factor reinforces the caution which must obviously be exercised in generalizing the results of studies such as this one.

Implications for Future Research

In terms of implications for future research, the study's findings suggest a number of areas that are likely to be fruitful. Continuing to utilize a multivariate statistical design of this nature should be useful in eliminating nonsignificant variables and in isolating those which ultimately can be used for early distinction of children with learning problems.

Additional possibilities for future research are also inherent in the study's findings. These possibilities stem from several threads of a more subjective, clinical nature that run through the data. While the statements made in the preceding discussion represent the statistically sound conclusions supported by the data, clinical experience provides the basis for further speculation. In surveying the findings, the experienced clinician is able to pick out a number of valuable cues for differentiating the two groups in spite of the lack of strong statistical validation. In fact, even as early as eight months there are clinical signs that an experienced individual working with the two groups would quite likely be able to use in distinguishing between the group members with a relatively high level of accuracy. The kinds of cues that such an individual would be attending to are primarily qualitative in nature. Hence, an area of significance for future investigation appears to be assessment of more qualitative variables. This possibility raises the question of whether many of the variables included in the current study and many past studies are investigating the appropriate variables for measuring differences between the two groups, especially at the younger ages. For example, assessing the quality of interaction between a child and the mother may be more successful than simply noting the presence or absence of a response on the child's part. This point is particularly cogent since the measurements most consistently able to detect differences between the study's two groups were the behavioral measures that reflected at least somewhat qualitative aspects of functioning (e.g., the nature of the child's activity).

Another important consideration for future research also relevant to the kinds of clinical signs alluded to above centers around the age levels at which children are examined. The present study was limited by the data collection periods of the COLR study; however, future research at ages between eight months and four years appears to be a promising area of study. It is likely that some of the differences which are only beginning to be picked up clinically at eight months in this study might be more capable of withstanding statistical scrutiny at even slightly later age levels. Again, this possibility appears most likely given greater emphasis upon examination of qualitative differences in functioning. From a clinical standpoint, one of the threads that runs through the data is the apparent importance of the quality of care and stimulation that the child receives at early ages. There is presumptive evidence that by combining data collection at the early ages missed in this study with examination of such factors as the quality of the mother-child interaction more successful early identification of children who will experience learning problems might be effected. In other words, it is highly likely that the study's findings are limited by much more than unreliable data and a questionable criterion group. The variables under investigation may simply not provide the most efficacious means of exploring learning problems at early ages. This contention is buttressed by the many studies which have validated the ability of teachers and other professionals to use clinical signs quite accurately in their assessments of children who are educationally at risk.

Several other factors meriting consideration in future research are also suggested in the present findings. In this study, the age range of the mothers was not great. In fact, the mean age was 23, and one-half of all the children's mothers fell within the age range from 19 to 25. Only four were over 34, and nine were under 16. Exploration of the relationship between the mother's age at the time of the child's birth and the incidence of learning problems might prove to be an area of concern as it has been shown to be for other anomalies (e.g., Down's Syndrome and a variety of birth defects). In addition, the consistency among a number of the neurological variables at birth (despite the surprising direction of the results) gives some indication that this area may be worthy of further investigation. If replication of this portion of the study were possible, it might prove helpful in discerning the influence of chance factors and unreliable data from other more constant differences in neurological functioning not clear upon the basis of current knowledge. Still other important areas to consider include the development of more refined behavioral measures and empirical examination of the interrelationships among racial and cultural factors and learning problems.

CHAPTER VII

SUMMARY AND CONCLUSIONS

The literature concerning learning disabilities is rife with theoretical disagreement and inconclusive research findings. Much of this discordance can be attributed to the relatively recent evolution of the field. Although the existence of debilitating conditions which inhibit the learning process has long been recognized, interest in learning disabilities per se has a much shorter history. Thus, there are many aspects of the field still to be clarified. Among these the characteristics which distinguish learning disabled from successful school children and which therefore allow for early prediction of later problems stand out. This study was a further attempt to provide information about the characteristics which can distinguish learning disabled from successful school children at an early age.

Ninety-two children enrolled in the Memphis Public School System at the time of the study's outset were selected for inclusion. Forty-six had been classified as learning disabled while the remaining 46 had no record of academic difficulties. Data collected in an earlier longitudinal study at four different age levels--birth, eight months, four years, and seven years--were analyzed. The data included socio-economic information as well as information and assessments from medical and psychological evaluations. Four stepwise linear discriminant function analyses were run to determine which variables distinguished the learning disabled and control groups at a level greater than chance. In addition, a prediction system composed of the variables providing the optimal level of classification into groups was provided. Cross validation studies at each age evinced how well the prediction system generated in the analysis held up in differentiating the groups.

The results obtained reveal that for the data included in this study prediction is not accurate beyond a chance level for the early ages (birth and eight months). However, when a child is nearing school age (four years), the ability to distinguish between a learning disabled and an academically successful population increases. Furthermore, the ability to differentiate the subjects and to classify the groups correctly in cross validation is greatly increased after a child has already entered school (by seven years). Although this general trend from less to more accurate predictability with increasing age was strongly upheld in the current study, there are a number of problems with data reliability and accuracy of the learning disability diagnosis that appear to have confounded the study's results. In addition, data were not available for a substantial segment of time between eight months and four years. Thus, it must be emphasized that this trend is indicated for the black youngsters of lower socioeconomic status included within this particular study.

It is purported that a study of this scope able to control for the previously discussed difficulties would be likely to provide more conclusive results than were obtained here. Even though the general trend of more successful prediction with increasing age might be upheld, it is further speculated that earlier distinction between the groups might be possible. Also results with greater clarity at the individual stages might also be obtained. For this study, the most consistent and clear cut results from the four and seven year analyses are that the children diagnosed as learning disabled exhibit the kinds of attentional deficits and concomitant behavioral difficulties frequently described in the literature. These children also appear, in general, to be less proficient in the verbal language or integrative skills which mediate success in school and on psychological test performance. In this study, the attentional difficulties were picked up most clearly from the behavioral observations while the language difficulties were detected through psychological evaluation. Consistent with Small's observation (1973) that the classical neurological approach has limited value in diagnosing these children, the neurological data included in this study served primarily as a source of confusion in attempting to interpret the results. Further study attempting to replicate and clarify the findings from the neurological examination was recommended, however, because of the consistency of the early findings.

Along with the comments included in the preceding chapter, these statements illustrate that very little in the way of statistically sound conclusions can be drawn from the results of this study. There are too many confounding influences present in the data and the criterion groups used. Foremost among these is the high probability that the children who were classified as learning disabled within the school system did not actually represent a learning disabled population in the strict sense of the term. While these children had obviously experienced difficulties in school as evidenced by their referrals, their problems assessed on the basis of the seven year psychological data appear to be of a more general nature that might be anticipated on the basis of other limiting factors. The test results from the COLR study provide evidence supporting the inference that these children actually comprised a heterogeneous group of "slow learners" rather than a truly learning disabled population. That they were all black children from lower socioeconomic status homes raises the question of confounding effects due to cultural disadvantage.

The nature of these findings obviously provides the basis for urging caution in assigning the learning disability diagnosis. For the label to continue to be a useful tool in helping to identify and remediate the learning problems of individual children, it must be protected from excessive, careless, or nonspecific use.

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APPENDIX

VARIABLES EXCLUDED FROM FINAL ANALYSIS

AT BIRTH AND SEVEN YEARS

Variables Excluded from Final Analysis at Birth and Seven Years

For the analyses conducted at birth and at seven years, the number of variables exceeded the computer's capacity. Therefore, an initial run was made, and the variables found least significant statistically were then dropped to allow the computer to accommodate the remaining variables. The variables listed below are the ones dropped from these two analyses.

Birth

Father primary caretaker

Babysitter primary caretaker

Day care facility primary caretaker

Income at child's birth (in intervals of $1500)

Breech delivery

Delivery of placenta spontaneous

Abnormal fetal heart rhythm

Age of mother at birth

Separated sutures

Molding (abnormal head condition)

Disorganized respirations

Retracted respirations

Palmar grasp

Plantar grasp

Cry absent

Tone of lower extremity normal

Seven Years

Total Bender time

Direction of WISC Verbal-Performance discrepancy

Range of WISC subtest scatter

Fearfulness

Self-confidence

Emotional reactivity

Degree of cooperation

Degree of dependency

Level of activity

Hostility

Head circumference

Chest circumference

Abnormal heart rate

Abnormal heart rhythm

Nystagmus

Fifth motor nerve

Fifth sensory nerve

Seventh motor nerve

Eighth nerve (hearing)
    low frequency
    high frequency

Ninth and tenth nerves (palate symmetry and elevation)

Phonation

Eleventh nerve

Twelfth nerve

Tone of upper extremity
    hypotonic, normal, hypertonic

Tone of lower extremity
hypotonic, normal, hypertonic

Tone of neck flexor
hypotonic, normal, hypertonic

Tone of neck extensor
hypotonic, normal, hypertonic

Tone of trunk
hypotonic, normal, hypertonic

Coordination (neurologist's assessment)

Station

Gait

Biceps jerk

Tricep jerk

Knee jerk

Ankle jerk

Sustained ankle clonus

Income at age seven (in intervals of $1500)

VITA

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